California High-Speed Rail Ridership and Revenue Model

Version 2.0 Model Documentation

final

report

prepared for

California High-Speed Rail Authority

prepared by

Cambridge Systematics, Inc.

April 11, 2014

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date

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1.0 Introduction and Model System Overview

1.1 INTRODUCTION

Since 2007, Cambridge Systematics (CS) has been supporting the California High-Speed Rail Authority (CAHSRA) by producing ridership and revenue (R&R) forecasts for different high-speed rail (HSR) service options. CS developed the "Version 1" model, which was estimated and calibrated using data from the 2000-2001 California Household Travel Survey (CHTS) and a stated-preference survey conducted in 2005 for the express purpose of HSR R&R forecasting.[1] The Version 1 model was used to support alternatives analyses and project-level environmental work.

In preparation for the 2012 Business Plan, CS updated the Version 1 model based on a new trip frequency survey of long-distance travel made by California residents and recalibrated it to 2008 conditions. The enhancements culminated in R&R model runs used to support the California High-Speed Rail 2012 Business Plan.[2]

In 2012 and 2013, CS made additional enhancements to the R&R model to accommodate the evolving forecasting needs of the Authority, including the 2014 Business Plan. The enhanced model, known as Version 2.0, represents a major overhaul of all model components, incorporates new and reanalyzed data, and reflects the most current thinking about California's future. The enhancements to the Version 2.0 model incorporated the recommendations of the Authority's Ridership Technical Advisory Panel (RTAP) and considered comments from the Authority's Peer Review Group (PRG) and the General Accountability Office's report. In addition to model enhancements, CS used a risk analysis approach to prepare and present ridership and revenue forecasts.

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[1] Cambridge Systematics, Inc., *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study: Interregional Model System Development*, prepared for the Metropolitan Transportation Commission (MTC) and CAHSRA, August 2006.

[2] Cambridge Systematics, Inc., *California High-Speed Rail 2012 Business Plan, Ridership, and Revenue Forecasting, Final Technical Memorandum*, prepared for Parsons Brinckerhoff for the CAHSRA, April 12, 2012.

1.2 Overview of Version 2.0 Model

The Version 2.0 Model includes the following components:

- **Long-Distance Travel –** Trips within California that are 50 or more miles long, measured by straight-line distance length; and
- **Short-Distance Travel within the Southern California Association of Governments (SCAG) and MTC Regions**[3] **–** Trips that are less than 50 miles long measured by straight-line distance that are made within the SCAG and MTC regions.

This is a departure from the Version 1 model, which modeled interregional and intraregional trips separately, but which allowed interregional trips to be of the short-distance variety.

Figure 1.1 shows the components in the Version 2.0 Model. The long-distance model estimates trip frequency, destination choice, and access/egress and main mode choice stratified by trip purpose (business, commute, recreation, and other). The long-distance trip frequency models estimates induced travel based on improved accessibilities due to high-speed rail options.

The short-distance model uses static trip tables that are based on the SCAG and MTC Metropolitan Planning Organization (MPO) models at particular horizon years, and estimates mode choice of these urban area trips. These mode choice models reflect local urban area highway and transit systems, as well as options for high-speed rail within the region. The short-distance mode choice models are based on the MTC Baycast[4] model and modified to include high-speed. The intraregional short-distance travel within the SCAG and MTC regions is stratified by the trip purposes more commonly used in trip-based regional models: home-based work, home-based shop, home-based recreation/other, nonhome-based work, and nonhome-based other.

The transit assignments from the long-distance model and the two intraregional models of short-distance travel are merged to produce total ridership and revenue on the HSR and other public modes.

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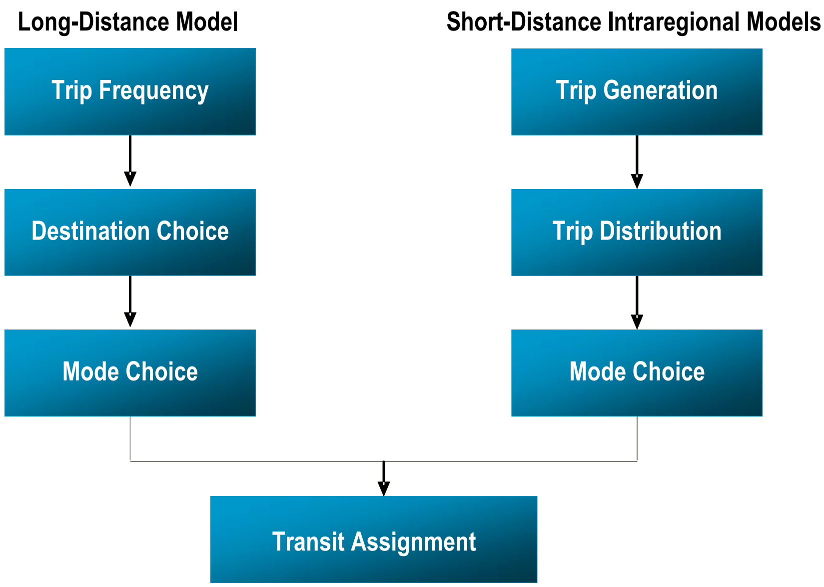
[3] The Southern California Association of Governments (SCAG) region encompasses six counties: Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura). The Metropolitan Transportation Commission (MTC) region encompasses nine counties in the San Francisco Bay Area: San Francisco, Alameda, Santa Clara, Contra Costa, San Mateo, Marin, Sonoma, Solano, and Napa.

[4] Metropolitan Transportation Commission, *Travel Demand Models for the San Francisco Bay Area (BAYCAST-90) Technical Summary*, June 1997.

Figure 1.1 Version 2.0 Model Components



1.3 Long-Distance Model

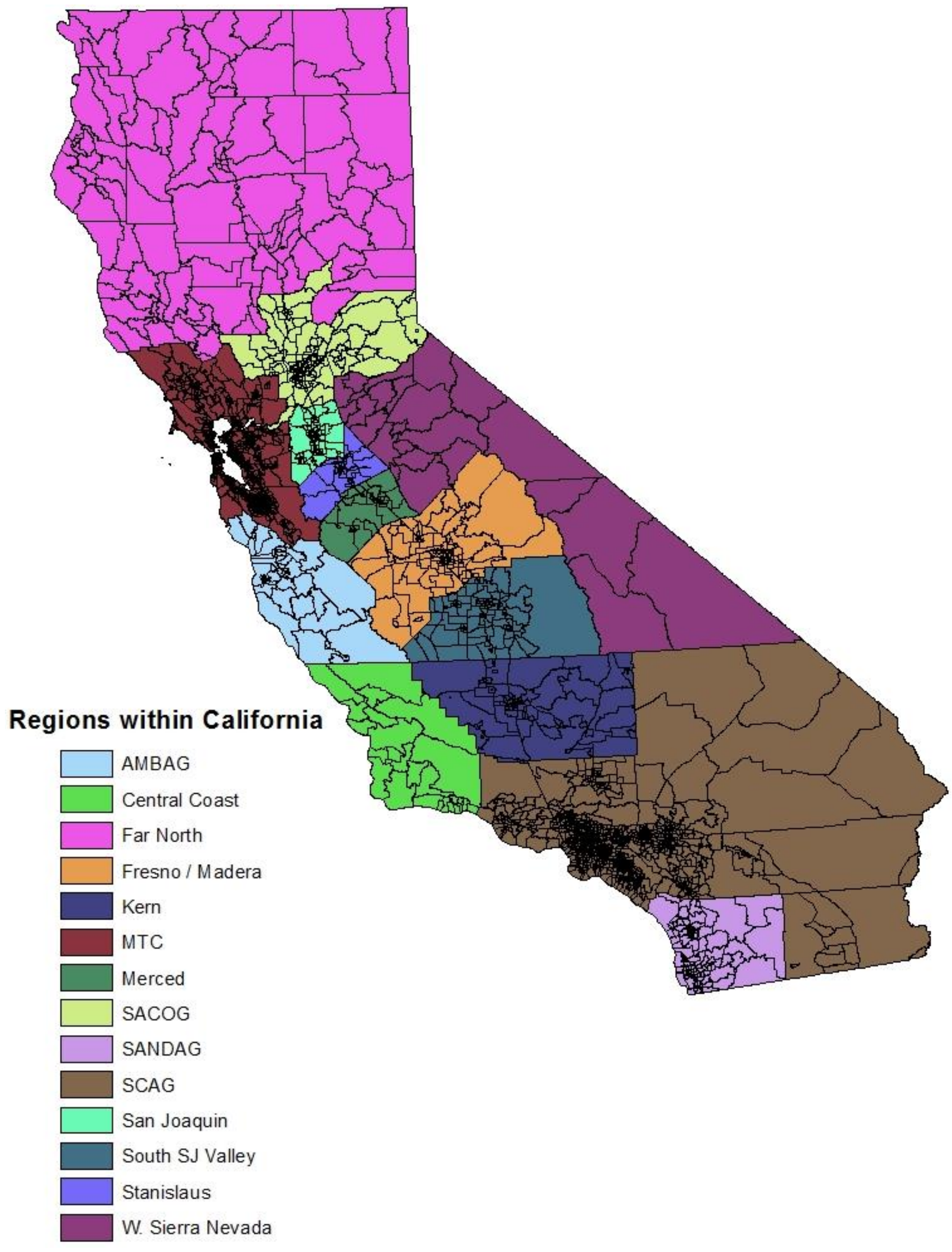
Long-distance trips are defined as any trip made to a Traffic Analysis Zone (TAZ) 50 miles or more from the respondent's home TAZ with one end of the trip at home and the other a location within California. All distances are calculated as straight line distances between TAZ centroids. This means that the following travel is not included (in addition to all short-distance trips, less than 50 miles in length):

- Nonhome-based travel occurring more than 50 miles from home;
- Trips by visitors to California; and
- Trips with one end outside of California.

Ignoring these trips tends to reduce the expected ridership and revenue for high-speed rail, making the forecasts conservatively low. While not inconsequential, these trips are expected to make up only a small fraction of overall high-speed rail ridership. Moreover, the difficulty and expense of collecting data and producing reliable estimates for these markets would be substantial, relative to their importance in overall high-speed rail ridership. For these reasons, the above markets were not modeled.

Figure 1.2 shows the TAZ system (outlined in black) and the 14 regions within the State (indicated by colors). The long-distance model uses the TAZ system comprising 4,683 zones as the primary unit of geography within the model, but the regions are used during calibration of the destination choice and trip frequency model and to summarize model output.

Figure 1.2 Long-Distance Model TAZs and Regions



The long-distance model is stratified by four trip purposes:

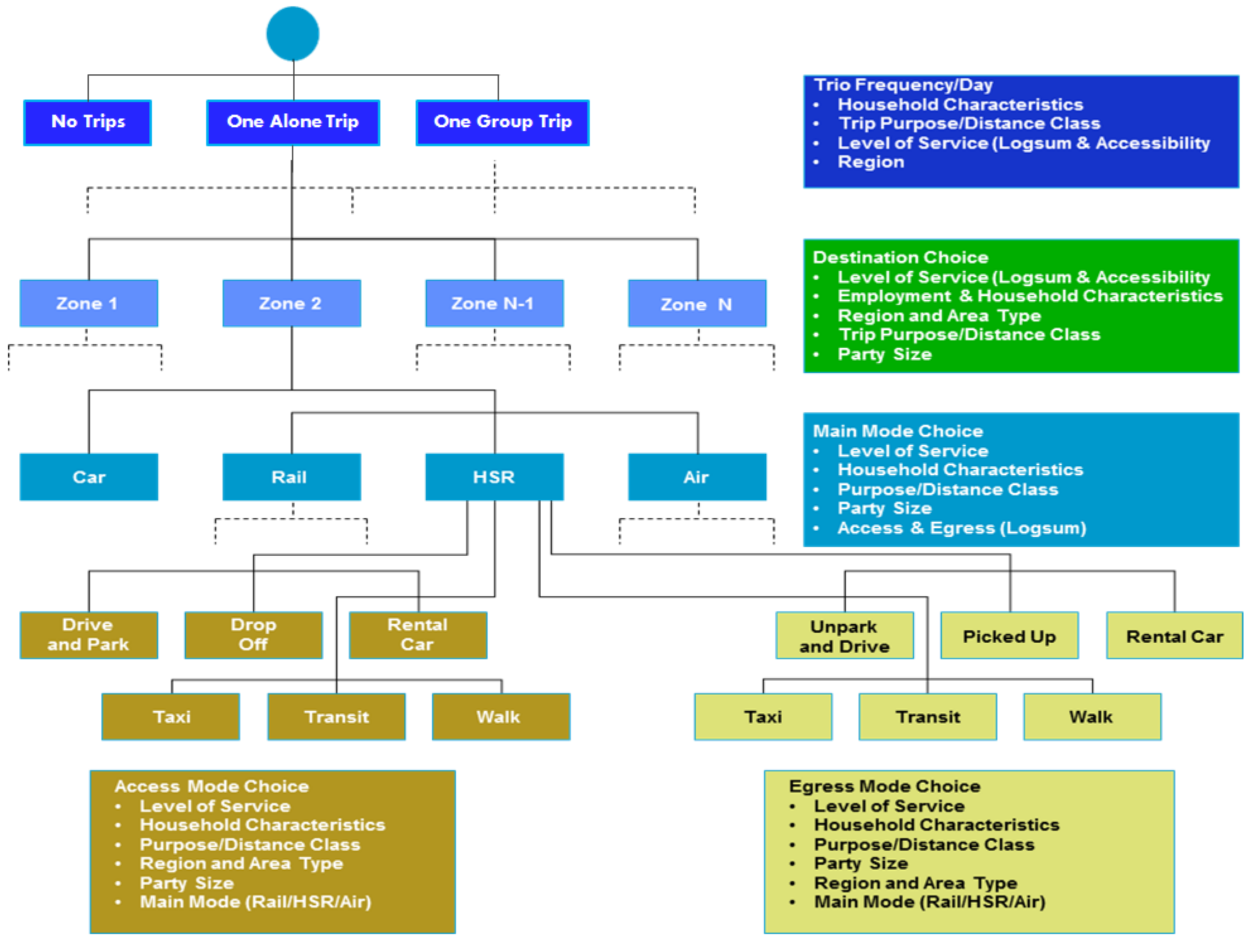
1. **Business** – Includes all business travel to locations other than a traveler's normal place of work.
2. **Commute –** Includes all travel to a person's regular place of work. Note that a person might work from home three or more days per week, but travel to an assigned office more than 50 miles from their home one or two days per week. Such travel is included in the commute category.
3. **Recreation –** Includes all trips made for recreation, vacations, leisure, or entertainment.
4. **Other –** Includes all trips made for other purposes, such as school, visiting friends or relatives, medical, personal business, weddings, and funerals.

The overall structure of the long-distance model is illustrated in Figure 1.3. The primary components are the following submodels:

- **Trip frequency model**, which estimates the number of trips taken by a household on an average day, in the following categories:
  - Zero;
  - One alone; or
  - One in a group.

  The model uses household and zonal characteristics and destination choice logsums.
- **Destination choice model**, which estimates the destinations of home-based trips based on distance from the origin zone, destination zonal characteristics, and main mode choice logsums.
- **Mode choice model**, which estimates the choice of main mode (e.g., auto, air, conventional rail, or high-speed rail), as well as access/egress mode. The mode choice model uses transportation level-of-service information, zonal characteristics of access and egress airports and rail stations, and household characteristics.

Figure 1.3 Long-Distance Model Structure



1.4 SHORT-DISTANCE INTRAREGIONAL MODELS

Short-distance trips (less than 50 miles in length) that take place within the SCAG or MTC region are modeled with separate intraregional mode choice models. Both the SCAG and MTC intraregional mode choice models use the structure shown in Figure 1.4 and are based on the MTC Baycast model. The models use static trip tables adopted from SCAG and MTC's regional models.[5] In addition, the models use transportation level-of-service characteristics and household

[5] Southern California Association of Governments, *SCAG Regional Travel Demand Model and 2008 Model Validation*, June 2012; and Metropolitan Transportation Commission, *Travel Model Development: Calibration and Validation*, May 2012.

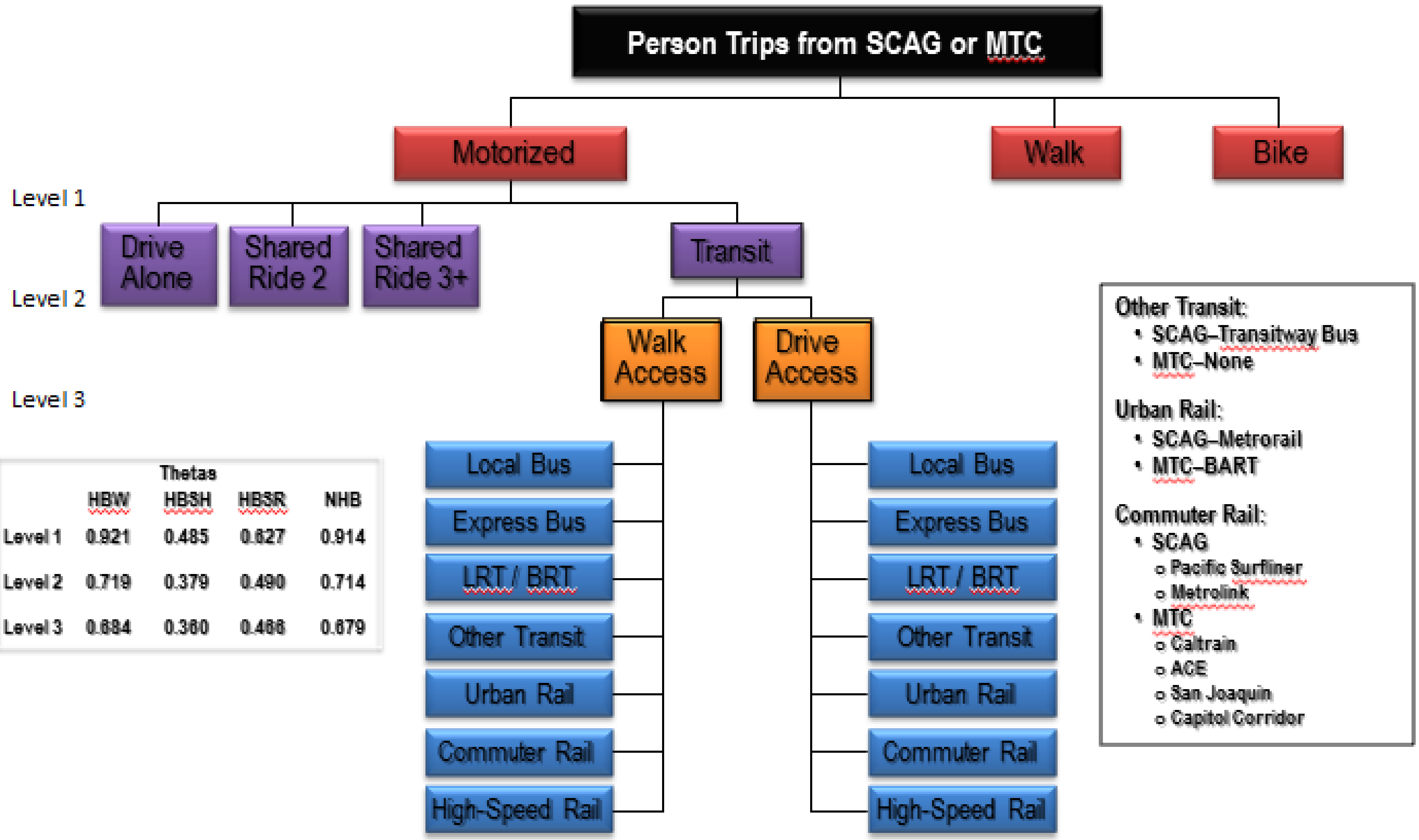
characteristics developed specifically for the high-speed rail model system. The models are stratified by trip purpose:

- Home-based work;
- Home-based shop;
- Home-based recreation/other;
- Nonhome-based work; and
- Nonhome-based other.

The mode choice model considers the following modes:

- **Auto Modes:**
  - Drive Alone;
  - Shared Ride 2; and
  - Shared Ride 3.
- **Nonmotorized Modes:**
  - Walk; and
  - Bike.
- **Transit Modes:**
  - Local bus;
  - Express bus;
  - Light rail, bus rapid transit (BRT), and ferry;
  - Other transit (i.e., Transitway Bus for SCAG, none for MTC);
  - Urban rail (e.g., BART, Metrolink);
  - Commuter rail (i.e., Conventional Rail (CVR)); and
  - High-speed rail.

Figure 1.4 Intraregional Model Overview



Thetas

	HBW	HBSH	HBSR	NHB
Level 1	0.921	0.485	0.627	0.914
Level 2	0.719	0.379	0.490	0.714
Level 3	0.684	0.360	0.466	0.679

1.5 VERSION 2.0 AND VERSION 1 DIFFERENCES

The Version 2.0 model represents a major overhaul of all model components, incorporates new and reanalyzed data, and reflects the most current thinking about California's future. Table 1.1 outlines the differences between the Version 1.0 and Version 2.0 long-distance model. Table 1.2 and Table 1.3 outline the differences between the Version 1.0 and Version 2.0 intraregional SCAG and MTC short-distance models.

Table 1.1 Long-Distance Models

Item	Version 1.0	Version 2.0
Model Structure	• Separate "interregional" models for short distance (less than 100 miles) and long distance (100 miles or more) • Conventional rail limited to lines that crossed regional boundaries	• Combined model that includes all long-distance trips 50 miles or more from home • Intraregional trips less than 50 miles are modeled using SCAG and MTC intraregional models • Conventional rail includes all CVR
Model Estimation Data	• 2005 stated-preference data • 2001-2002 California Household Travel Survey data (without a true long-distance travel component) • Interregional trips from 2000 Urban household travel surveys performed for SCAG, MTC, and Sacramento Area Council of Governments (SACOG) regions	• 2012-2013 California Household Travel Survey data from long-distance travel component • 2005 stated-preference and revealed-preference data
Model Calibration and Validation Data	• 2001-2002 California Statewide Household Travel Survey data (without a true long-distance travel component) • 1995 American Traveler Survey (ATS) data • 2000 Census Transportation Planning Package (CTPP) data • U.S. Department of Transportation (DOT) Federal Aviation Administration (FAA) origin-destination (O&D) 10-percent ticket sample for 2000-2005 • Rail passengers in 2000 by operator and route • Year 2000 traffic count data	• 2012-2013 California Household Travel Survey data weighted to year 2010 • U.S. DOT FAA O&D 10-percent ticket sample for 2009 • Rail passengers in 2010 by operator and route
Socioeconomic Data	• 2005 data compiled from the California DOT (Caltrans) and MPOs • 99 market segmentation categories for household characteristics • Three employment categories	• Compiled from 2010 population synthesis data developed for California Statewide Travel Demand Model • 99 market segmentation categories for household characteristics • Nine employment categories

Item	Version 1.0	Version 2.0
Highway Network and Skims	• 2005 network and skim data compiled from Caltrans network and MPO networks • Separate peak and off-peak skims used for auto • Peak-period skims are the average of AM and PM peak periods • Off-peak skims are the average of midday and night periods	• 2010 network and skim data compiled from the University of California at Davis (UCD) for the Caltrans Statewide Travel Demand Model network • Peak period is represented by the AM peak • All models use an average of peak and off-peak congested speeds from the California Statewide Travel Demand Model
Station-to-Station Skims	• Slightly different processes and assumptions for HSR and CVR skims • Reliability matrix was developed external to model	• Identical processes and assumptions for HSR and CVR skims • Generalized cost assumptions are coordinated between skims and based on model coefficients • Skims use a reliability look-up table and determine reliability based on number of transfers
Station Assignment Skims	• Path-building includes all mode options • Uses post-skimming scripts to check for and then eliminate unreasonable paths to stations • All-or-nothing assignment from each TAZ to a single station that is insensitive to fares • Path-building weights differ between skims do not match mode choice model coefficients	• Path-building assumes drive-access to main mode only • Need for post skimming scripts to eliminate unreasonable paths was obviated by other network coding and modeling changes • All-or-nothing assignment that is insensitive to fares (same as Version 1.0) • Path-building weights are consistent across skims and mode choice model coefficients
Access/Egress Skims	• Constrained drive access distance to no more than 50 miles to CVR stations and 100 miles to airports and HSR stations • Conventional rail access to air and HSR was not included • Transit skims based on all-or-nothing assignments that were insensitive to fares • One set of transit skims for air, CVR, and HSR • Separate walk access and drive access skims • Skims developed for closest TAZ centroids to stations or airports • Parking costs at stations added into toll costs • Path-building weights differ between skims do not match mode choice model coefficients	• No limits on drive access distance to airports, CVR stations, or HSR stations • Conventional rail access to air and HSR is included • Transit skims based on multipath assignments that are sensitive to fares • Separate skims for airports and CVR and HSR stations to allow for mode-specific transit access modes • Combined walk and drive access skims for consistency • "Dummy" TAZ centroids added at locations of airports and CVR and HSR stations • Parking costs, parking availability, and rental car availability included as separate input variables • Path-building weights are consistent across skims and mode choice model coefficients

Item	Version 1.0	Version 2.0
Access/Egress Mode Choice Model	• Estimated with 2005 RP and SP data and 2005 skims • Model estimated independently of Main Mode Choice Model • No restrictions on mode availability • Access/Egress mode shares from the model were not used and instead were developed using a postprocessor	• Estimated with 2005 RP data, 2012-2013 CHTS Data and 2010 skims • Model estimated jointly with Main Mode Choice Model • Revised restrictions on modal availability • Access/Egress Mode share results used directly
Main Mode Choice Model	• Estimated with 2005 SP data and original 2005 skims • Coefficients on level-of-service variables were developed independently of Access/Egress Mode Choice Model • Short-distance (<100 miles) interregional and long-distance (≥ 100 miles) interregional models were estimated separately	• Estimated with 2005 RP and SP data, 2012-2013 CHTS Data, and 2010 skims • Model estimated jointly with Main Mode Choice Model • Single long-distance travel (≥ 50 miles) model • Refined specification of reliability variable
Destination Choice Model	• Estimated with 2005 RP and SP data and original 2005 skims	• Estimated with 2012-2013 CHTS Data • Fewer constrained variables • More disaggregate employment categories used • Added Impact of Disneyland and Yosemite on recreation travel • Less reliance on district-district constants during calibration
Trip Frequency Model	• Estimated with 2005 RP and SP data and original 2005 skims • Separate estimation of trip frequency and alone/ group travel	• Estimated with 2012-2013 CHTS Data • Combined estimation of trip frequency and travel alone-group travel • Less reliance on district constants during calibration
Calibration, Validation, and Sensitivity Testing	• Calibration to year 2000 survey data • Validation to year 2000 observed data	• Calibration to 2012-13 CHTS survey data • Validation to year 2010 observed data • Validation by backcasting to 2000 • Multiple model runs to determine sensitivity to different variables and elasticities • Sensitivity testing using characteristics similar to the Northeast Corridor (NEC-like)

Table 1.2 SCAG Intraregional Model

Item	Version 1.0	Version 2.0
Skims	• Only allowed modification of HSR skims; All other skims were borrowed from SCAG's model • Path-building and mode choice parameters were not consistent	• All transit skims were developed as part of intra-SCAG model system • Auto skims are borrowed from SCAG's model • Transit skims were modified to ensure consistency with intra-MTC and Long-distance Model skimming process • Consistent path-building and mode choice parameters (using the approach favored by the Federal Transit Administration)
Person Trip Tables	• From SCAG's 4,000+ zone model • Trip purposes included Home-based work, home-based shop, home-based recreation/other, and nonhome-based • Forecast year trip tables were static and could not be easily modified for different socioeconomic forecasts	• Aggregated from SCAG's 12,000+ zone model into SCAG's 4000+ zone system • Trip purposes included Home-based work, home-based shop, home-based recreation/other, nonhome-based work, and nonhome-based other • Forecast year trip tables are updated based on SCAG's trip generation model and forecast year socioeconomic data
Market Segments for Home-Based Work Trip purpose	• 3 Income Groups	• Segmentation as follows: – 0 vehicle households – Households with fewer vehicles than workers – 3 income groups for households with vehicles >= workers
Zonal Socioeconomic Data File	• From SCAG's 4,000+ zone model • Forecast Year socioeconomic data was inconsistent with Interregional Model	• Socioeconomic data file modified so that there would be consistent categories between the SCAG and MTC regions. • Socioeconomic data, for each model year, is consistent with long-distance socioeconomic data
Mode Choice	• MTC region Baycast model modified in certain ways for SCAG application	• MTC's Baycast model modified for use in the SCAG and MTC intraregional models (i.e., model structure is identical for SCAG and MTC)
Transit Assignment and Summarizing Procedure	• Unique to Intra-SCAG model	• Generic Intraregional model process

Table 1.3 MTC Intraregional Model

Item	Version 1.0	Version 2.0
Skims	• All transit skims developed as part of intra-MTC model system • Auto skims are from MTC's Baycast model • Path-building and mode choice parameters are not consistent	• All transit skims developed as part of intra-MTC model system • Transit skims were modified to ensure consistency with intra-SCAG and Long-Distance Model skimming process • Auto and nonmotorized skims are borrowed from MTC's activity-based model • Consistent path-building and mode choice parameters (using the approach favored by the Federal Transit Administration (FTA))
Person Trip Tables	• Taken directly from MTC's Baycast model • Forecast year trip tables were static and could not be easily modified for different socioeconomic forecasts	• Aggregated from MTC's activity-based model trip rosters • Forecast year trip tables are updated based on SCAG's trip generation model and forecast year socioeconomic data
Market Segments for HBWork	• 4 Income Groups	Segmentation as follows: • 0 vehicle households • Households with fewer vehicles than workers • 3 income groups for households with vehicles >= workers
Zonal SE File	• Structure based on MTC's Baycast model • Forecast year socioeconomic data was inconsistent with Interregional Model	• Socioeconomic data file modified so that there would be consistent categories between the SCAG and MTC regions. • Socioeconomic data for each model year is consistent with long-distance socioeconomic data
Mode Choice	• MTC-specific translation of Transbay model for MTC region	• MTC's Baycast model modified for use in the SCAG and MTC intraregional models (i.e., model structure is identical for SCAG and MTC)
Transit Assignment and Summarizing Procedure	• Unique to Intra-MTC model	• Generic Intraregional model process

1.6 CONTENTS OF REPORT

This report documents the Version 2.0 R&R model. Applications of the model are documented elsewhere, such as for the 2014 Business Plan.[6] The remainder of this section is an overview of the model system with references to sections where details are provided. Section 2.0 describes the travel survey datasets used for model estimation and calibration. The next sections document the long-distance model:

- Section 3.0 – Long-distance model input data;
- Section 4.0 – Long-distance model skims;
- Section 5.0 – Long-distance model estimation; and
- Section 6.0 – Long-distance model calibration.

Section 7.0 describes how the short-distance intraregional models were developed and calibrated. Section 8.0 documents the validation of the model and describes the sensitivity analysis.

[6] Cambridge Systematics, Inc., *California High-Speed Rail Draft 2014 Business Plan, Ridership and Revenue Forecasting, Draft Technical Memorandum*, February 6, 2014.

2.0 Travel Survey Datasets Used for Model Estimation and Calibration

2.1 Introduction

Two travel survey datasets were used for model estimation and calibration. The first is a 2005 combined revealed and stated-preference (RP/SP) survey. This RP/SP survey was the primary survey used in estimation of the Version 1 Ridership and Revenue model ("the Version 1 model"). Early in the development of the Version 2.0 model, the 2012 CHTS data became available. This survey is a typical household travel survey, but covers the entire State of California and includes a long-distance travel component.

Each of the datasets has specific strengths and weaknesses for a variety of reasons, including data collection methods and purpose of data collection, among others. For instance, the coverage of the 2012 CHTS is quite good, making it appropriate for expansion to the State and use in calibration. However, due to the relatively low incidence of long-distance trips observed with the one-day diary, an optional long-distance recall survey also was included. While the recall survey succeeded in increased observations of long-distance trips significantly, it still observed a relatively low incidence of nonauto mode trips long-distance trips in the observed dataset. On the other hand, the 2005 RP/SP survey was specifically directed at capturing respondents from different mode options; therefore, the modal data is more diverse.

Table 2.1 shows how the datasets were used for model estimation and calibration of each individual model component. Due to the fundamental difference between revealed and stated-preference data, the 2005 RP and SP portions are split in Table 2.1. The SP data was used solely in the main mode choice model estimation, and served as the only dataset with any information about HSR preferences. Along with the 2005 RP portion, these datasets were most important for estimation of the access/egress and main mode choice models. The 2012 CHTS survey was most important for calibration of each model component and estimation of the trip frequency model.

The following sections describe each of the datasets in more detail.

Table 2.1 Survey Use in Model Estimation/Calibration

	2005 RP Data	2005 SP Data	2012 CHTS Data
Estimation			
Access/Egress Mode Choice	Yes	No	No
Main Mode Choice	Yes	Yes	Yes
Destination Choice	Yes	No	Yes
Trip Frequency	No	No	Yes
Calibration			
Access/Egress Mode Choice	Yes	No	Yes
Main Mode Choice	No	No	Yes
Destination Choice	No	No	Yes
Trip Frequency	No	No	Yes

2.2 2012 CHTS DATA

This section describes and summarizes the data sources used to estimate existing long-distance travel within the State of California. The primary data source is the long-distance recall survey component of the CHTS. This survey was conducted using the long-distance travel log, an optional element of the CHTS. However, use of the long-distance recall survey without other data sources would have severely underestimated both the total magnitude and relative characteristics of the existing long-distance travel markets. Therefore, other available data sources were used to complete this analysis, including:

- The 2012 CHTS Daily Diary;
- The Harris On-Line Panel Long-Distance conducted in 2011;
- The 2010 U.S. Census; and
- 2010 population synthesis of the California household population.

The Version 2.0 model used the daily diary and long-distance recall data collected for the CHTS, which was performed for Caltrans. The raw (unexpanded) data were used for estimation of Version 2.0's discrete choice trip frequency, destination choice, and mode choice models.

We also used the expanded long-distance CHTS data to estimate control totals for model calibration. Both the daily diary and long-distance recall survey components of the CHTS were used to estimate daily long-distance trip-making within California.

This section describes the processes used to tabulate the survey data, to identify and rectify biases within the survey data, and to expand the survey dataset to represent the residential population of the State of California.

Summary of Findings from CHTS Analysis

Significant findings of the analysis include:

- Work-related trip purposes (commute and business trips) account for 26 percent of long-distance trips, while recreational and other trip purposes account for the remaining 74 percent.
- Trip rates show reasonable variations by socioeconomic characteristics. For example, per-capita trip rates for high-income households were observed to be more than twice as high as trip rates for low-income households.
- Residents of rural areas account for significantly higher long-distance trip rates (11 annual trips per capita) than residents of urban areas (7.6 annual trips per capita).
- Mode shares for all long-distance trips within California are dominated by the auto mode, accounting for 96 percent of all long-distance trips. Even for very long trips of more than 400 miles, the auto mode accounts for two-thirds of all person trips. The airplane mode, which accounts for fewer than 2 percent of all long-distance trips, accounts for 25 to 30 percent of trips of more than 300 miles. Bus and rail modes each account for approximately 1 percent of total long-distance trips for all trip lengths.
- Residents traveling on business trips are much more likely to use the airplane mode (6 percent) than residents traveling for other trip purposes (less than 2 percent).
- Residents traveling alone are much more likely to use nonauto modes (7 percent) than persons traveling in groups (2 percent).

Our understanding of long-distance travel in California has changed since the development of the Version 1 model in 2006-2007. The Version 1 model was calibrated to estimated long-distance travel for a 2005 base year based on a combination of 1995 ATS, 2000 CTPP, and 2001 CHTS data. Changes in estimates of intra-California long-distance travel include the following:

- Commute work trips were estimated to account for approximately 40 percent of statewide long-distance travel in 2005. The expanded 2012-2013 CHTS data indicated that long-distance commute work trips now account for about 16 percent of such travel. One possible explanation is the "dot-com" boom in the Silicon Valley was strong during the 1995 through 2001 period when the data for estimating 2005 long-distance travel was collected.
- Air travel was previously estimated to account for approximately 50 percent of long-distance travel for trips over 300 miles. The expanded 2012-2013 CHTS data indicates that air travel now accounts for approximately

27 percent these trips. The decrease in the dot-com boom, the changes in air travel due to the terrorist attacks of 9/11/2001, and the 2008 recession would all contribute to the decrease in air travel.

- Significantly fewer very long-distance trips (more than 300 miles in length) have been estimated based on the 2012-2013 CHTS data than were estimated for 2005 for the Version 1 model. Again, the changes in air travel due to 9/11 and the 2008 recession could contribute to the decrease.

While typical, one-day travel diaries can provide some useful information regarding long-distance travel, they are an inefficient source of information for the detailed analysis of long-distance travel. Since long-distance travel is a relatively rare occurrence for most households, the average person makes approximately nine long-distance round-trips per year; most households will not report any long-distance travel in a survey collecting travel data for a single travel day. In fact, only five percent of households participating in the CHTS reported any long-distance trips in their daily diaries.

The next sections describe how three recent surveys performed in California have been used to provide an overall picture of long-distance travel within the State. The three surveys are the 2011 Harris On-Line Panel Long-Distance survey performed for the CAHSRA and the CHTS Daily Diary and Long-Distance Travel Recall Surveys.

Definition of "Long-Distance Trips" in this Analysis

Long-distance trips are defined as trips from the home region of the survey respondent to locations within California more than 50 miles from the traveler's residence. Distances are calculated using geographic information system (GIS) to calculate the straight-line distance between geocoded origin and destination locations. Long-distance trips by California residents to other states and countries are not addressed in this analysis. Nonhome-based, long-distance travel is not addressed in this analysis, although survey data suggests that nonhome-based trips account for approximately three percent of long-distance trips. Long-distance travel by nonresident visitors to California also is not included in this analysis.

Definition of "Population" in this Analysis

The residential population of California accounts for approximately 95 percent of the total population, which was measured at 37.34 million in the 2010 census. The remaining (nonresidential) population lives in group quarter arrangements, such as prisons, long-term care facilities, college dormitories, and military barracks. The group quarter residents were not subject to independent data collection in any of the surveys, but it is reasonable to assume that this segment of the population accounts for less long-distance travel than the residential population. Therefore, we expanded the survey data to the residential population only, ignoring travel from group quarters.

To maintain consistency within this report, all per-capita trip rates refer to the residential population.

2012-2013 CHTS Daily Diary Survey

Caltrans carried out a comprehensive household travel survey of all members of 42,431 respondent households using multiple methods of data collection, including computer-aided telephone collection, on-line data entry by respondents, and mail-back of survey forms. A stratified sampling procedure was used to ensure that the number of surveys collected from each county exceeded specified minimum quotas. CS obtained the Caltrans dataset and analyzed it to use in the Version 2.0 model.

Data Collection and Analysis Process

Caltrans collected travel data for each member of a respondent household during the travel day appointed for the household. The travel diary was designed to collect information necessary to calibrate and validate either trip-based or activity-based travel models. The data included:

- Characteristics of each respondent household;
- The household members;
- The vehicles owned by the household;
- The places visited;
- Activities performed at those places;
- Time of travel; and
- Modes of travel between places visited.

More than 3,600 households declined to report household income and were dropped from the database used for the analysis of long-distance travel. The remaining 38,787 households with all socioeconomic data reported were used to estimate long-distance travel behavior for the diary day.

While a one-day travel diary is well suited for collecting typical travel data, it is not the ideal instrument for collecting long-distance travel data. Even with a sample size of more than 100,000 persons in the 38,787 households, a single-day diary collects long-distance travel data for a very small proportion of travelers and households. In fact, our analysis of the results of the CHTS daily diary survey found that only five percent of respondent household made a long-distance trip on the appointed diary date.

Since daily diaries are designed to collect information for only the assigned travel day, it often is impossible to determine the true purpose for long-distance travel. For example, a person may travel for a business meeting scheduled for the day following the assigned travel day. That traveler's final trip (or tour) on the assigned travel day may end at a hotel, leaving the true purpose of the trip unreported.

Nevertheless, the strength of the daily diary survey is that it provides a good mechanism for identifying all long-distance travel completed by members of respondent households on the assigned travel day. The information collected using the daily diary method is much more accurate than the recall data collected with the long-distance travel log. Thus, it is a very strong tool for validating overall rates of long-distance travel estimated using data from long-distance recall surveys.

In our analysis, long-distance trips were estimated from the daily diary data using a process similar to determining tours for tour-based travel models:

- A TOUR was defined by listing all PLACES visited between two stops at the HOME location.
- For each TOUR, the PLACE farthest from the HOME location (based on straight line distances) was determined.
- If the farthest place visited was 50 miles or more from the HOME location, the location was identified as the long-distance DESTINATION.
- Distances were calculated using GIS to calculate the straight-line distance between geocoded HOME and DESTINATION locations.
- Each long-distance DESTINATION determined from the above three steps defined an end-point for two, one-way long-distance trips (since the traveler, in the case defined by the above three steps, left and returned home on the assigned travel day).
- For trips that began or ended the travel day at a location other than HOME, the trip was counted as a single one-way long-distance trip if the non-HOME location was 50 miles or more from HOME.
- Long-distance trips that included a stop outside the State of California were not counted as long-distance trips, even if the TOUR defining the long-distance trip included a stop within California that was 50 or more miles from HOME.

This process avoided double-counting long-distance trips from the daily diary and maintained consistency with the long-distance travel data reported in the recall surveys. The goal was to "link out" intermediate stops for incidentals such as gas or food.

The above analysis identified 3,210 long-distance trips completed by 3,199 persons (i.e., 11 persons made more than one long-distance trip on their diary day). A significant portion (53 percent) of the long-distance travel involved overnight stays, so those travelers were credited with completing one-half of a long-distance round-trip. Therefore, the 3,210 long-distance trips recorded in the survey accounted for 4,713 one-way trips, or the equivalent of 2,356 long-distance round-trips. Since multiple household members traveled together to a significant number of the identified long-distance locations, 1,201 of the long-distance person trips were consolidated into larger group trips. Thus, the survey identified long-distance trips to 2,009 unique locations. In all, long-distance trips were identified for 1,965; or 5 percent of the 38,787 households included in the CHTS data used for the analysis.

CS expanded the surveyed long-distance trips to represent long-distance travel for all California households on the assigned travel day. The expansion factors were based on geographic and demographic characteristics of the surveyed households, as compared to those characteristics for all households in California. (See section titled *Expansion Process* for details.) After the expansion factors were applied to the CHTS daily diary database, we estimated that more than 1.5 million one-way long-distance trips were made by California residents on an average day. Based on expanded results from the CHTS data, the long-distance trips account for approximately two percent of all intrastate trips made by California residents.

The 1.5 million daily one-way long-distance trips equate to an average trip rate of 8.2 annual intrastate, long-distance round-trips per capita for California household residents. In comparison, a National Passenger Transportation Survey (NPTS) Brief from 2006[7] estimated the national average of 9.4 annual long-distance round-trip rate per capita; for the Pacific Region, the annual average was 8.7 long-distance trips per capita. When interstate and international long-distance trips reported in the CHTS daily diary also are included in the analysis, the average round-trip rate is 8.6 annual long-distance trips per capita, which is almost identical to the value reported in the NPTS for the Pacific Region.

Summary of Findings Regarding Usefulness of CHTS Daily Diary Data for Long-Distance Travel Analysis

The data from the CHTS Daily Diary provided a good basis for determining the overall amount of intrastate long-distance travel made by California residents. However, even though the CHTS dataset included information from 38,787 households, long-distance trip-making is such a rare occurrence that making estimates of variations in trip rates by geographic region of the State or different socioeconomic strata has not been performed. In addition, since the diary covered only one day of travel, it is not possible to reliably determine the purposes of the long-distance trips reported in the diary. Therefore, we supplemented the daily diary data with data from the Long-Distance Travel Recall survey, which also conducted by Caltrans.

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[7] NPTS Brief, March 2006, U.S. Department of Transportation Federal Highway Administration, http://nhts.ornl.gov/briefs/LongDistanceTravel.pdf, accessed July 30, 2013.

2012-2013 CHTS Long-Distance Travel Recall Survey

The Long-Distance Travel Log was an optional survey conducted by Caltrans that requested long-distance travel performed by the members of the respondent households during the eight weeks preceding the assigned travel day. The longer survey period (56 days, as compared to one day for the daily diary) greatly increased the amount of long-distance travel data available for analysis.

Data Collection and Analysis Process

The Long-Distance Travel Log was designed to reduce respondent burden by requesting information deemed relevant for most transportation planning studies:

- Trip origin and destination;
- Trip purpose;
- Group size (total and household members); and
- The main mode of travel used on the trip.

Respondents were instructed to record the information listed above for all long-distance trips completed during the eight-week reporting period to places 50 miles or more from their home. One recall survey form with spaces for up to eight long-distance trips was provided for each household member. Respondents were instructed to record outbound and return trips separately, and to record details for trips in excess of the eight spaces available on the travel log on a separate sheet of paper.

Long-distance travel data were provided by only about one-half of CHTS respondent households since it was optional. The Long-Distance Travel Log collected data for 32,641 long-distance person trips completed by 22,555 individuals from 12,183 households. Another 9,834 households completed the Long-Distance Travel Log, but indicated either no long-distance trips or long-distance trips only to non-California locations. Approximately nine times as many trips to unique locations, 18,023, were identified in the Long-Distance Travel Log as were identified in the daily diary. The larger number of trips to unique locations resulted in a much richer database for analyzing and understanding long-distance travel in California.

When the 32,641 long-distance person trips reported in the Long-Distance Travel Log were initially expanded to represent the entire population of California, approximately 680,000 daily one-way long-distance trips, or an average of 3.6 annual long-distance round-trips per capita, were estimated. By comparison, this estimate accounts for less than one-half the 1.5 million daily long-distance trips – or 8.2 annual long-distance round-trips per capita – calculated using the data derived from the CHTS daily diary. The analysis and processes used to account for and correct these differences are documented in the following sections of this report.

Summary of Findings Regarding Usefulness of CHTS Long-Distance Recall Survey Data for Long-Distance Travel Analysis

The Long-Distance Travel Log provided a rich database for determining long-distance trip purposes and the destination and main mode choice characteristics of intrastate long-distance travel made by California residents. Since discrete choice models of trip frequency, destination choice, and mode choice were being developed for the Version 2.0 model, the unexpanded trip data could be used to estimate model forms and coefficients. Thus, the fact that the total amount of long-distance travel based on the Long-Distance Travel Log was less than one-half the amount of travel estimated using the daily diary did not preclude the use of the Long-Distance Travel Log data for model estimation. However, procedures to adjust the Long-Distance Travel Log data to reflect all intrastate long-distance travel had to be developed for the data to be useful for final calibration of the CAHSR^{3}M.

The initial analysis of the Long-Distance Travel Log data revealed several survey design issues that had to be addressed:

- The Long-Distance Travel Log did not include a "repetition frequency" question, which would have allowed respondents who made multiple long-distance trips to the same location through the same travel mode to quickly report the repeated trips. An analysis of the responses, along with the number of Long-Distance Travel Logs with exactly eight trips, suggested that respondent fatigue, coupled with a lack of understanding of the need for respondents to report all long-distance travel, was an important issue.
- The Long-Distance Travel Log required respondents to remember and report travel completed as far back as eight weeks prior to their assigned travel day. The recall survey was subject to memory lapses, resulting in underreporting of long-distance trips.
- Many respondents failed to record both directions of travel. On average, for every outbound trip, only 65 percent of return trips were recorded.
- The long-distance recall survey was not subject to the same rigorous process to make sure that all trips completed by all household members were reported by the survey respondent.
- Since completion of only the CHTS Daily Diary was required for a survey to be considered to be complete, only about one-half of the respondent households completed the Long-Distance Travel Log. Household characteristics and trip-making characteristics for households completing and households choosing not to complete the Long-Distance Travel Log were therefore different.

Since the Long-Distance Travel Log was the primary data source for compiling validation datasets of total long-distance travel made by California residents, each of the issues outlined above had to be addressed before reasonable estimates of travel could be produced. The following sections describe how the

2011 Harris Panel survey and CHTS daily diary survey were used to complete the compilation of the validation datasets.

2011 Harris On-Line Panel Long-Distance Survey

CS subcontracted with Harris Interactive to conduct an on-line panel long-distance survey in May and June 2011, in an effort to collect information for corroborating trip rates and shares of trips by trip purpose forecast using the Version 1 Model. The Harris Panel survey was used to update the Version 1 model for use in the 2012 Business Plan.[8] The survey design[9] was similar to the CHTS long-distance recall survey, in that, travel over the previous eight-week period was requested. However, there were several distinct differences:

- Survey respondents were drawn from established on-line panels that respond to selected surveys in order to accrue credit for awards and prizes.
- Demographic information on the panelists, such as age, sex, household size, and household income, was obtained from panelists' on-line panel registration information. Worker status of the survey respondents was collected later to aid in the socioeconomic classification of the participants.
- Due to the need to limit response time for the survey, only the destination city or zip code was requested for each trip rather than detailed address information.
- Also, due to the need to limit the response time for the on-line survey, respondents were requested to provide a repeat frequency for multiple trips made to the same destination for the same purpose and using the same mode during the eight-week recall period. This shortcut resulted in the finding that many long-distance trips are repeated on a regular basis.
- The survey collected long-distance travel information only for the panel member rather than for all household members. This allowed survey respondents to provide information about their own long-distance travel during a single Internet session without requiring interviews of other household members.
- The survey panel included only adult household members.

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8 Revised 2012 Business Plan, April 2012, California High-Speed Rail Authority, http://www.hsr.ca.gov/docs/about/business_plans/BPlan_2012_rpt.pdf, accessed July 30, 2013.

9 California High-Speed Rail 2012 Business Plan Ridership and Revenue Forecasting, April 22, 2012, prepared by Cambridge Systematics, Inc. for the California High-Speed Rail Authority, http://www.hsr.ca.gov/docs/about/business_plans/BPlan_2012Ch5_RidershipRevForecasting.pdf, accessed July 30, 2013.

- The survey was conducted over a two-month period rather than over a complete year.

Data Collection and Analysis Process

The two-month recall period covered by the 2011 Harris Panel survey (April and May 2011) represented a typical time of year when most employed residents were working and most students were in school. More long-distance trips would be expected during the summer months for vacation travel, and fewer long-distance trips would be expected during the winter months. The survey timeframe included a major holiday weekend (Memorial Day) that is often associated with recreational weekend travel. The inclusion of one major holiday weekend was appropriate for the two-month survey timeframe, since almost any two-month time period during the calendar year includes one such major holiday weekend.

The 2011 Harris Panel survey collected useful long-distance travel information for 11,986 California residents. These residents reported making more than 25,000 one-way long-distance trips during the two-month survey recall period. This total included more than 11,200 one-way long-distance trips to unique locations. Each unique trip was factored by the reported repeat frequency over the previous two months. The average trip repetition frequency reported by the Harris Panel survey respondents was 2.23 repetitions for each trip. The repeat frequency varied significantly by trip purpose (commute trips had by far the highest repeat frequency) and trip length (shorter trips had higher repeat frequencies than longer trips). Based on the reported trips, coupled with repeat frequencies and adjustments for household members accompanying the survey respondents on trips, the Harris survey identified approximately 1.13 million daily long-distance trips within the State of California, or an annual average of 6 long-distance intrastate round-trips per capita. This average trips rate is approximately 65 percent higher than the trip rate calculated for the CHTS Long-Distance Travel Log, but 30 percent lower than the trip rate calculated for the CHTS Daily Diary.

Summary of Findings Regarding Usefulness of 2011 Harris Panel Long-Distance Survey Data for Long-Distance Travel Analysis

The 2011 Harris Panel survey was designed to collect long-distance travel characteristics of adult California residents. The original intent of the survey was to validate long-distance trip-making forecast using the Version 1 Model. With limited time and resources available, and with the knowledge that a more comprehensive statewide household survey would not be ready for another 12 months, the Harris Panel survey was used as a stop-gap measure to evaluate long-distance trip frequency, shares of trips by trip purpose, average trip lengths, travel group sizes, and mode shares.

The following issues impact the usefulness of the 2011 Harris Panel survey data for long-distance travel analysis:

- The survey was not a random sample of California residents since respondents were drawn from an established on-line panel that responds to selected surveys in order to accrue credit for awards and prizes.
- Long-distance trip information was collected for only the respondents, not all members of the respondents' households. While adjustments were made for household members accompanying respondents on their reported trips, trips made by other household members independently of the survey respondents were not recorded.
- The survey did not collect detailed origin and destination location information.

The 2011 Harris Panel survey data provides information for one important variable that is missing from the Long-Distance Travel Log: an estimate of repeat frequency for long-distance trips. The following section describes how this information was combined with the data collected through the 2012-2013 CHTS Long-Distance Recall survey to improve estimates of total intrastate long-distance travel made by California residents.

Methods for Expanding and Adjusting the 2012-2013 CHTS Long-Distance Recall Survey

The previous section provided background on the three sets of survey data available for estimating total intrastate long-distance travel made by California residents. Issues were identified with each of the surveys that limited the usefulness of the data for the estimates of total travel. However, by combining information from each of the surveys, a reasonable estimate of the total travel can be made:

- The 2012-2013 CHTS Daily Diary data provided a reasonable estimate of the amount of average daily intrastate long-distance trips made by California residents, which corresponds closely with the estimate of long-distance trip-making from the NPTS. The Daily Diary estimate was used to adjust for underreporting of long-distance trips in the 2012-2013 CHTS Long-Distance Recall survey.
- The 2012-2013 CHTS Long-Distance Recall survey data provided the most complete data regarding the purpose, origins and destinations, and mode shares of long-distance trips.
- The 2011 Harris Panel survey provided data regarding the repeat frequency for long-distance trips, which was used to adjust reported trips by trip purpose and trip length in the 2012-2013 CHTS Long-Distance Recall survey.

We adjusted the 2012-2013 CHTS Long-Distance Recall survey using this procedure:

- Only information from one direction of travel was used. This solved the issue that 35 percent of respondents reported information only for outbound trips, and a much smaller number reported information only for return trips. We assumed that all intrastate long-distance trips were symmetrical, meaning that every one-way trip was accompanied by an identical return trip.
- We developed an imputation procedure to account for repeat frequency that randomly assigned repeat frequencies from the 2011 Harris Survey on Long-Distance Travel Log data based on trip purpose, trip distance, and traveler socioeconomic data.
- Based on the observation of a systematic under-reporting of long-distance trips less than 200 miles in length, we applied distance-based adjustment factors based on the 2012-2013 CHTS Daily Diary data to address remaining differences between overall trip rates from the adjusted Long-Distance Travel Log data.

Expansion Process

The survey was conducted in 2012 and 2013, but we factored the survey to match 2010 socioeconomic characteristics of California households summarized from a synthesis of the California population produced by HBA Specto from their work on the California Statewide Travel Demand Model (CSTDM) for Caltrans.

We expanded surveyed trip records to represent more than 12.58 million households in the California by comparing the numbers of completed surveys to the number of households within the State. A four-dimensional cross-classification scheme developed for the Version 1 model resulted in 99 possible socioeconomic strata (Table 2.2).

Table 2.2 Four-Dimensional Socioeconomic Cross-Classification Scheme

Dimension	Strata
Household size	1, 2, 3, or 4+ persons
Worker per household	0, 1, or 2+ workers
Vehicles per household	0, 1, or 2+ vehicles
Annual household income range for 2010	Low-income: < $45,000 Medium-income: $45,000-$89,999 High-income >= $90,000

The expansion factors also were stratified by five geographic regions. Four of the regions were defined by the major metropolitan planning regions:

1. Los Angeles metropolitan area as defined by the SCAG region,
2. San Francisco Bay area as defined by the MTC region,
3. San Diego Association of Governments (SANDAG) region,
4. SACOG region, and
5. Remainder of the State.

We tabulated the Long-Distance Travel Log survey records into each cell of the cross-classification scheme. We aggregated cells to maintain at least 15 observations for use in survey expansion. Expansion factors for each cell of the cross-classification were developed by dividing the number of households in the 2010 population synthesis by the number of survey households.

Expansion factors varied from 102 to 4,427 with a weighted average expansion factor of 572. The wide range for the expansion factor resulted from several factors, including both intentional sampling procedures to achieve minimum quotas in geographical regions and unintentional biases due to the willingness of different demographic groups to participate in the survey. The intentional oversampling of smaller regions resulted in smaller expansion factors for those regions, especially in comparison to the SCAG and MTC regions.

Correction Process

Imputation of Repeat Trips. The Long-Distance Travel Log did not include a trip repetition frequency question, but we estimated an average frequency of 1.2 by summarizing the numbers of long-distance trips in the Long-Distance Travel Log made by each respondent to the same location, for the same trip purpose, and by the same mode. In comparison, the average trip repetition frequency summarized from the 2011 Harris Panel survey, which did include a question regarding trip repetition frequency, was 2.2 repetitions for each trip.

We developed a procedure to adjust for the underreporting of repeat trips in the Long-Distance Travel Log to replace the trip repetition frequency information from the Long-Distance Travel Log with imputed trip repetition derived from the 2011 Harris Panel survey. The 2011 Harris Panel data showed that trip repetition frequency was correlated with trip purpose (commute trips have the highest repetition frequency) and trip length (shorter trips have higher repetition frequency than longer trips). In addition, for the commute trip purpose, it was clear that household income was important to trip repetition frequency. Double-counting of reported repeat trips in the Long-Distance Travel Log was averted by removing the reported repeat trips so that only "unique" long-distance trips were included in the database. The imputation process was then completed by randomly assigning a repeat frequency rate from the Harris Survey data based on the trip purpose, trip length and, in the case of commute trips, income group of the respondent.

Table 2.3 shows the result of the trip repetition frequency imputation. The imputed repetition frequency rates are substantially higher for commute trips than for the other trip purposes. The expanded data in the last two columns show the results for each of the categories before and after imputation. Imputation increased the number of trips for all trip purposes with the greatest impact on the commute trip purpose. The average repetition frequency reported for commute trips in the Long-Distance Travel Log survey was two repeats per unique trip; whereas, the average repetition frequency reported for commute trips in the Harris Survey was 15. Imputation increased the number of commute trips from 23,250, or 3 percent of total long-distance trips, to 87,285, or 15 percent of total long-distance trips.

Table 2.3 Impact of Trip Repetition Frequency Imputation on Long-Distance Trips

Trip Purpose	Distance Range (Miles)	Income Range(s)	Reported Repetition Frequency (LDTL)[a]	Imputed Repetition Frequency (Harris)[a]	Expanded Daily Long-Distance Trips: Before Imputing	Expanded Daily Long-Distance Trips: After Imputing
Commute	50-75	Medium, High	2.5	24.5	11,200	115,130
	50-300	Low	1.2	6.2	1,190	5,040
	75-300	Medium	1.6	18.2	2,660	31,970
	75-300	High	1.9	6.0	6,560	20,960
	Over 300	All	1.4	1.4	1,640	1,470
	All (over 50)	All	2.0	15.0	23,250	174,570
Percent of Total Long-Distance Trips					3%	15%
Business	50-75	All	1.2	2.2	23,790	44,890
	75-100	All	1.2	1.9	13,740	21,080
	100-150	All	1.1	1.8	12,170	18,810
	150-300	All	1.1	1.7	8,980	13,490
	Over 300	All	1.1	1.6	11,370	16,080
	All (over 50)	All	1.2	1.9	70,050	114,350
Percent of Total Long-Distance Trips					10%	10%
Recreation and Other	50-75	All	1.2	1.9	190,560	318,920
	75-100	All	1.2	1.7	126,370	185,510
	100-150	All	1.1	1.5	120,410	164,590
	150-300	All	1.1	1.4	92,440	119,760
	Over 300	All	1.1	1.2	60,900	68,890
	All (over 50)	All	1.1	1.6	590,680	857,670
Percent of Total Long-Distance Trips					86%	75%
All Purposes					**683,980**	**1,146,590**

Source: Cambridge Systematics, Inc.

[a] During the eight-week recall period.

Correction for Missing Trips. After imputation, we expanded the adjusted trips to represent the total intrastate long-distance trip-making by California residents. The adjusted, expanded trips summed to approximately 1.15 million daily intrastate long-distance one-way trips, or an average of 6.1 annual long-distance round-trips per capita – significantly lower than the 1.5 million daily long-distance trips (8.2 per capita) calculated from the CHTS daily diary.

We surmised that the cause of the difference was underreporting of trips for the reasons described previously:

- Only eight spaces on the Long-Distance Travel Log forms,
- Forgotten trips due to the eight-week recall period, and
- Differences between the respondents that reported long-distance travel and those who did not complete the long-distance recall survey.

It was not possible to isolate these sources of underreporting independently. However, when the expanded, adjusted Long-Distance Travel Log dataset and the expanded long-distance trips from the CHTS daily diary were tabulated and compared by trip distance, it was clear that most of the trips missing from the imputed/expanded Long-Distance Travel Log dataset were shorter trips, particularly those between 50 and 200 miles. For trip lengths of more than 200 miles, we found an almost identical number of trips were estimated for the two expanded datasets. We believe this is because shorter trips are more likely to be forgotten with the recall survey, especially for trips made more than a month prior to the reporting date and trips made by household members other than the survey respondent.

We calculated adjustment factors stratified by 25-mile bins to correct the differences between the Daily Diary and the Long-Distance Travel Log surveys (as shown in Table 2.4).

Table 2.4 Adjustment Factors to Account for Missing Trips by Trip Length

Trip Length (Miles)	Adjustment Factor
50 and 75	1.41
75 to 100	1.38
100 to 125	1.36
125 to 150 miles	1.34
150 to 175 miles	1.31
175 to 200 miles	1.27
200 to 225 miles	1.22
225 to 250 miles	1.14
250 to 275 miles	1.06
>275	1.00

Summary of the Adjusted 2012-2013 CHTS Long-Distance Recall Survey Results

Comparison to Other Long-Distance Survey Data

We compared the overall results of the survey expansion and correction to other data sources to demonstrate the reasonableness of the results. This analysis presents a comparison of the following data sources:

- 1995 ATS, in which long-distance trips are defined as more than 100 miles;
- Version 1 Model (calibration year 2000);
- 2001 National Household Travel Survey (NHTS);
- 2009 NHTS, which did not have a separate long-distance component;
- 2011 Harris Survey (long-distance trips only, interstate travel not included);
- 2012 CHTS:
  - Daily Travel Diary,
  - Long-Distance Travel Log – Uncorrected, and
  - Long-Distance Travel Log – Corrected.

Overall Long-Distance Trip Rates. We compared the long-distance trip rates from the data sources listed above (Table 2.2), recognizing that some comparisons cannot be performed because of different data collection methods and definitions of long-distance trips. For example, the 1995 ATS defines long-distance trips as more than 100 miles; the 2009 NHTS does not include a separate long-distance component; and both the Version 1 model and the Harris Survey do not include short-distance travel.

Comparing long-distance data sources is complicated further by the fact that some sources report data aggregated to households and others are aggregated to persons. The data in Table 2.5 is aggregated to households. This explains why the overall trip rates are approximately three times the trip rates reported elsewhere in this document for persons.

The corrections applied to the CHTS Long-Distance Travel Log dataset results in reasonable estimates of long-distance travel. For example:

- For long-distance trips more than 100 miles long, the overall trip rate (11.32 annual trips per household) is close to the midpoint of the national data collected for the 1995 ATS (10.15 annual trips per household) and 2001 NHTS (12.32 annual trips per household);
- For long-distance trips more than 300 miles long, the overall trip rate (3.88 annual trips per household) is almost identical to the rate reported for the 2001 NHTS (3.87); and
- The trip rate for trips more than 300 miles within California (1.27 annual trips per household) is significantly lower than the similar rate calculated for the 2011 Harris Survey (1.77).

Table 2.5 Comparison of Annual Long-Distance Trip Rates per Household

Trip Length	1995 ATS	2001 NHTS	2009 NHTS	CA Only: 2000 HSRA Model 1	CA Only: Harris Survey	CSHTS Daily Diary: CA Only	CSHTS Daily Diary: Total USA	CSHTS LD Travel Log (Corrected): CA Only	CSHTS LD Travel Log (Corrected): Total USA
Total LD trips (more than 50 miles)		23.85		18.15	16.37	22.79	23.89	22.28	26.05
Mlore than 100 miles	10.15	12.32		7.25	6.80	6.67	7.50	7.73	11.32
More than 300 miles	3.51	3.87		2.39	1.77	0.95	1.52	1.27	3.88
100 to 300 miles	6.64	8.45		4.85	5.02	5.71	5.98	6.46	7.44
50 to 100 miles		11.53		10.91	9.58	16.12	16.39	14.55	14.73
Daily Person Trips and Person Miles per Household (CSHTS Data Include Short-Distance Trips from CSHTS Daily Diary)									
Person trips per household	10.49	9.66	9.5			9.96	9.96	9.94	9.97
PMT per household	94.41	95.24	90.42			62.09	67.61	58.23	81.49

Source: Cambridge Systematics, Inc.

Note: Analysis of the 1995 ATS, 2001 NHTS, and 2009 NHTS is presented in the NCHRP 735 Final Report.

Long-Distance Trip Length Frequency. The overall trip length frequencies for long-distance trips in 100-mile bins are compared in Table 2.6 across the three long-distance data sources available for California: there is a wide variation between the data sources.

Table 2.6 Trip Length Frequency Distribution by 100-Mile Bins

Bin (Miles)	2000 CA HSRA Model Version 1: Expanded	2000 CA HSRA Model Version 1: Cum. %	2011 Harris Survey: Expanded	2011 Harris Survey: Cum. %	CSHTS Daily Diary: Expanded	CSHTS Daily Diary: Cum. %	CSHTS LD Travel Log – Corrected: Expanded	CSHTS LD Travel Log – Corrected: Cum. %
50 to 100	751,957	60.10%	660,278	58.50%	995,252	64.80%	1,003,404	65.30%
100 to 200	275,662	82.10%	277,832	83.10%	392,042	90.30%	373,266	89.60%
200 to 300	58,809	86.80%	68,600	89.20%	77,228	95.30%	72,025	94.30%
300 to 400	72,257	92.60%	89,892	97.10%	50,867	98.60%	61,683	98.30%
400 to 500	60,532	97.40%	28,579	99.70%	17,591	99.80%	22,266	99.80%
500 to 600	24,699	99.40%	3,249	100.00%	2,754	100.00%	2,871	100.00%
600 to 700	5,336	99.80%	369	100.00%	478	100.00%	647	100.00%
700 to 800	2,286	100.00%	0	100.00%	0	100.00%	39	100.00%
Total	**1,251,539**		**1,128,799**		**1,536,211**		**1,536,200**	

Source: Cambridge Systematics, Inc.

As discussed previously, the 2012 CHTS Long-Distance Travel Log provides the most comprehensive source of information regarding long-distance trips in California. Applying the adjustments documented in the previous section of this report results in overall long-distance trip generation and trip length frequency distributions that are much more reasonable, as compared to other data sources (2001 NHTS and 2012 CHTS Daily Diary).

The overall trip length frequencies for long-distance trips in 25-mile bins are compared in Table 2.7 and Figure 2.1. Once again, the table and figure illustrate the wide variation in the data sources. The exhibits also demonstrate that the 2000 CAHSRA Model Version 1, which was validated using less comprehensive data and fewer independent data sources, varies from the data used to validate the current version of the CAHSRA Model, especially for long-distance trips of more than 350 miles in length.

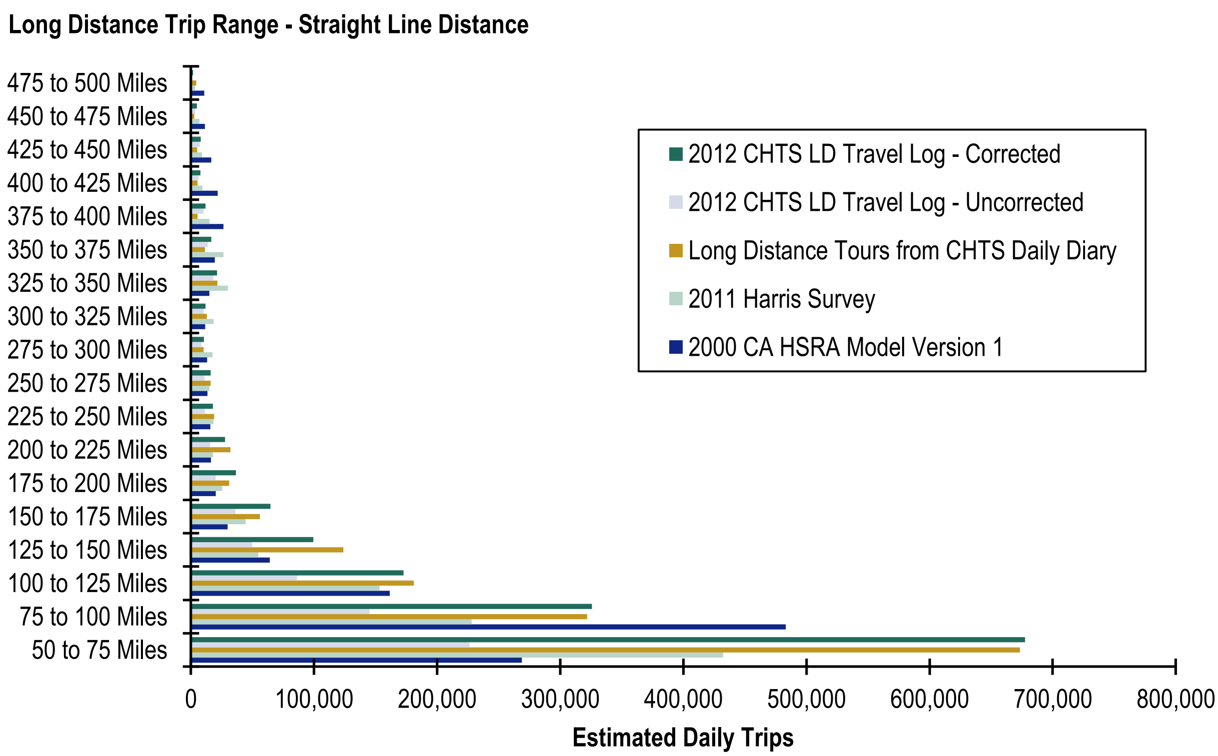
Table 2.7 Trip Length Frequency Distribution by 25-Mile Bins

Bin (Miles)	2000 CA HSRA Model Version 1		2011 Harris Survey		CSHTS Daily Diary		CSHTS LD Travel Log – Corrected	
	Expanded	Cum. %	Expanded	Cum. %	Expanded	Cum. %	Expanded	Cum. %
50 to 75	268,846	21.50%	432,213	38.30%	673,301	43.80%	677,640	44.10%
75 to 100	483,111	60.10%	228,065	58.50%	321,950	64.80%	325,764	65.30%
100 to 125	161,642	73.00%	153,331	72.10%	181,099	76.60%	172,690	76.60%
125 to 150	64,122	78.10%	54,838	76.90%	123,940	84.60%	99,485	83.00%
150 to 175	29,736	80.50%	44,271	80.90%	55,914	88.30%	64,544	87.20%
175 to 200	20,162	82.10%	25,393	83.10%	31,088	90.30%	36,547	89.60%
200 to 225	16,363	83.40%	17,868	84.70%	32,081	92.40%	27,611	91.40%
225 to 250	15,751	84.70%	18,270	86.30%	18,994	93.60%	17,784	92.60%
250 to 275	13,462	85.80%	14,899	87.60%	15,964	94.70%	15,950	93.60%
275 to 300	13,233	86.80%	17,562	89.20%	10,190	95.30%	10,681	94.30%
300 to 325	11,536	87.70%	18,424	90.80%	12,823	96.20%	11,992	95.10%
325 to 350	14,884	88.90%	30,053	93.50%	21,416	97.60%	21,192	96.50%
350 to 375	19,491	90.50%	26,296	95.80%	11,267	98.30%	16,649	97.50%
375 to 400	26,346	92.60%	15,118	97.10%	5,360	98.60%	11,850	98.30%
400 to 425	21,689	94.30%	9,168	98.00%	5,382	99.00%	7,711	98.80%
425 to 450	16,524	95.60%	8,945	98.80%	5,052	99.30%	7,984	99.30%
450 to 475	11,424	96.50%	7,049	99.40%	2,900	99.50%	4,874	99.70%
475 to 500	10,895	97.40%	3,417	99.70%	4,258	99.80%	1,696	99.80%
500 to 525	11,003	98.30%	968	99.80%	2,361	99.90%	1,406	99.90%
525 to 550	6,867	98.80%	530	99.80%	393	100.00%	834	99.90%
550 to 575	3,713	99.10%	1,036	99.90%	0	100.00%	106	99.90%

Bin (Miles)	2000 CA HSRA Model Version 1		2011 Harris Survey		CSHTS Daily Diary		CSHTS LD Travel Log – Corrected	
	Expanded	Cum. %	Expanded	Cum. %	Expanded	Cum. %	Expanded	Cum. %
575 to 600	3,116	99.40%	714	100.00%	0	100.00%	525	100.00%
600 to 625	2,235	99.60%	210	100.00%	478	100.00%	398	100.00%
625 to 650	1,182	99.70%	29	100.00%	0	100.00%	31	100.00%
650 to 675	963	99.70%	110	100.00%	0	100.00%	69	100.00%
675 to 700	956	99.80%	21	100.00%	0	100.00%	149	100.00%
700 to 725	1,102	99.90%	0	100.00%	0	100.00%	23	100.00%
725 to 750	883	100.00%	0	100.00%	0	100.00%	16	100.00%
750 to 775	198	100.00%	0	100.00%	0	100.00%	0	100.00%
775 to 800	103	100.00%	0	100.00%	0	100.00%	0	100.00%
Total	**1,251,539**		**1,128,799**		**1,536,211**		**1,536,200**	

Source: Cambridge Systematics, Inc.

Figure 2.1 Trip Length Frequency Distribution for Long-Distance Trips



Source: Cambridge Systematics, Inc.

Long-Distance Travel Log Survey Results

This section describes the CHTS Long-Distance Travel Log results after expansion and correction, covering trip frequency, trip length frequency, trip distribution, and mode shares. These tabulations are classified further by trip purpose, geographic region, socioeconomic characteristics, and group travel status.

Long-Distance Trip Frequency. Following the adjustment of the 2012 to 2013 CHSTS Long-Distance Recall survey expansion, 1.536 million daily intrastate long-distance trips have been estimated to be made by California residents. That level of trip-making represents an average of 8.2 annual long-distance round-trips per capita, which compares reasonably to the 9.4 annual long-distance round-trip rate per capita reported in the NPTS Brief from 2006[10]. The reported NPTS rate included all long-distance trips, not just intrastate trips. For the Pacific Region, the NPTS Brief reported an annual average of 8.7 long-distance round-trips per capita. When interstate and international long-distance trips reported in the CHTS are included in the analysis, the average annual long-distance round-trip rate is 8.6 trips per capita.

Long-Distance Trip Frequency by Purpose. The shares of trips by purpose are shown in Table 2.8. The most frequent type of trip was recorded to be "other," and the second most common was recreational.

Table 2.8 Long-Distance Trip Frequency by Purpose

Purpose	Percent
Business	10%
Commute	16%
Recreation	33%
Other	41%

Source: Cambridge Systematics, Inc.

Trip Frequency by Geographic Region. Table 2.9 summarizes the variation in average long-distance trip rates per capita by geographic region. The average trip rates are generally higher in rural areas and lower in urban areas. Average annual long-distance trip rates for the four largest urban areas vary from 7.2 to 8.4 per capita; whereas, these rates are greater than 10 trips per capita in rural areas.

[10] *Ibid*. 7

Table 2.9 Average Annual Intrastate Round-Trips per Capita by Geographic

Home Region	Average Annual Long-Distance Round-Trips per Capita
Southern California (SCAG) Region	7.2
Bay Area (MTC) Region	8.4
San Diego (SANDAG) Region	7.8
Sacramento (SACOG) Region	7.5
San Joaquin Valley Counties	11.6
Rest of State	10.1
Statewide	**8.2**

Source: Cambridge Systematics, Inc.

Trip Frequency by Socioeconomic Characteristics. Table 2.10 presents long-distance trip rates by socioeconomic classifications, cross-classified by trip purpose. The most powerful variables for explaining long-distance travel behavior are household income and auto availability – residents with higher incomes or more vehicles are more likely to make long-distance trips than residents with lower incomes or fewer automobiles available. There also is a strong inverse correlation with household size (i.e., residents of smaller households exhibit higher rates of long-distance travel than larger households, possibly due to the increased mobility of residents who do not have children).

Table 2.10 Annual Long-Distance Trip Rates by Socioeconomic Characteristics

	Annual Long-Distance Round-Trip Rates per Capita				
Value	**Business**	**Commute**	**Recreation**	**Other**	**Total**
Variable: Household Size					
1	1.23	2.25	2.75	5.12	**11.35**
2	1.19	1.6	3.21	4.39	**10.39**
3	0.78	1.39	2.41	3.14	**7.71**
4+	0.58	0.97	2.64	2.71	**6.9**
Total	0.8	1.29	2.73	3.35	**8.17**
Variable: Number of Workers					
0	0.49	0.44	2.19	4.1	**7.21**
1	0.82	1.51	2.73	3.42	**8.48**
2+	0.9	1.4	2.91	3.03	**8.25**
Total	0.8	1.29	2.73	3.35	**8.17**

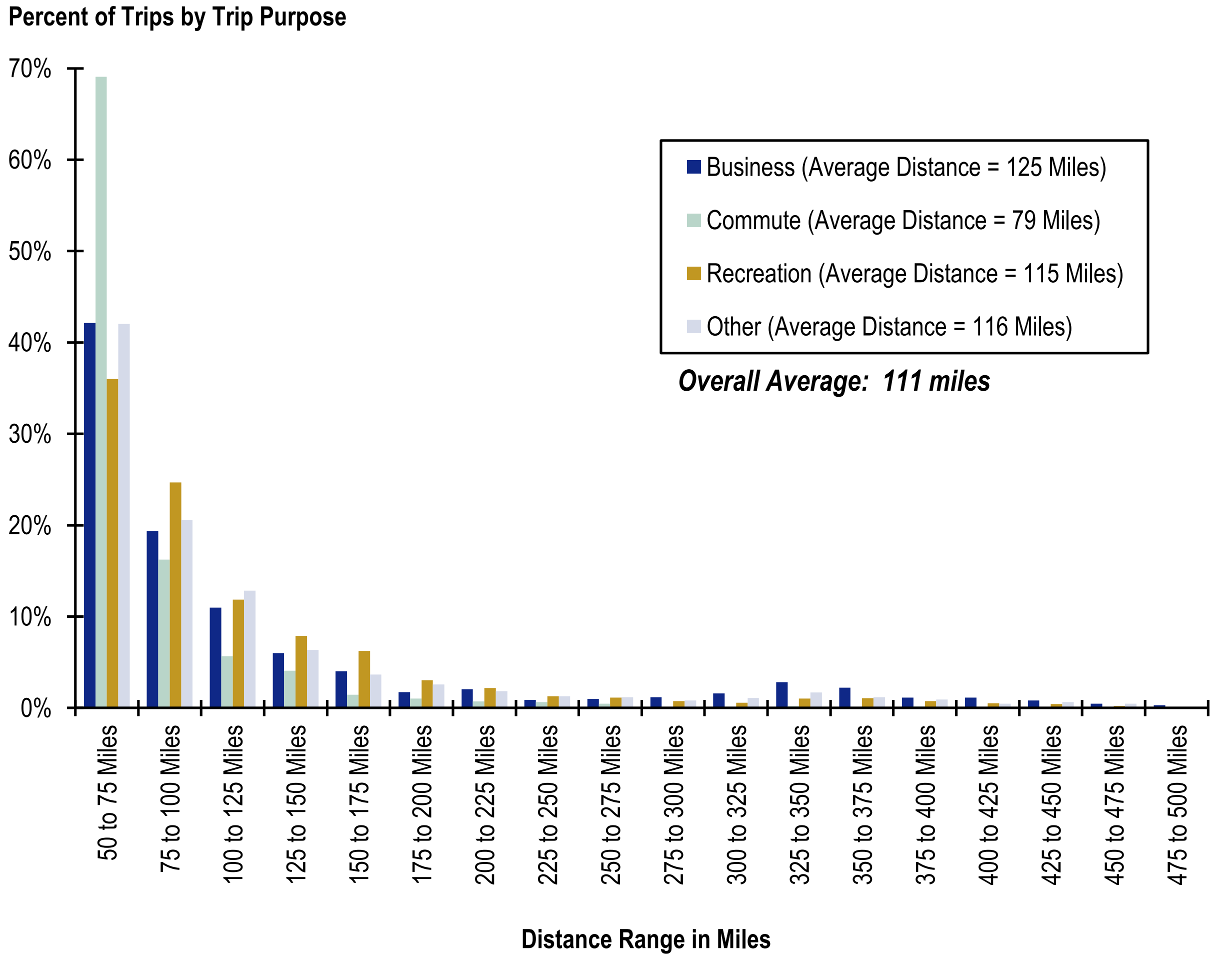
Value	Annual Long-Distance Round-Trip Rates per Capita				
	Business	Commute	Recreation	Other	Total
Variable: Number of Vehicles					
0	0.25	0.16	1.53	2.01	**3.94**
1	0.67	1.1	2.07	3.55	**7.39**
2+	0.89	1.44	3.04	3.4	**8.77**
Total	0.8	1.29	2.73	3.35	**8.17**
Variable: Income Range					
Low	0.37	0.21	1.55	2.8	**4.94**
Med	0.76	1.69	2.46	3.51	**8.43**
High	1.08	1.63	3.57	3.56	**9.84**
Total	0.8	1.29	2.73	3.35	**8.17**

Source: Cambridge Systematics, Inc.

Long-Distance Trip Length

Trip Length Frequency by Trip Purpose. Figure 2.2 displays the trip length frequency distributions of long-distance trips by trip purpose within California. The shares of commute trips decrease most rapidly with increasing trip distance, while the other three trip purposes show similar decreases in shares with increasing trip distances. The trip length frequency distributions for the business, recreation, and other trip purposes show a slight "hump" in shares in the 300- to 375-mile distance range. That slight increase in trips in that distance range reflects travel between the major metropolitan areas in Northern California (the San Francisco and Sacramento areas) and the major metropolitan areas in Southern California (the Los Angeles and San Diego areas).

Figure 2.2 Long-Distance Trip Length Distribution by Purpose

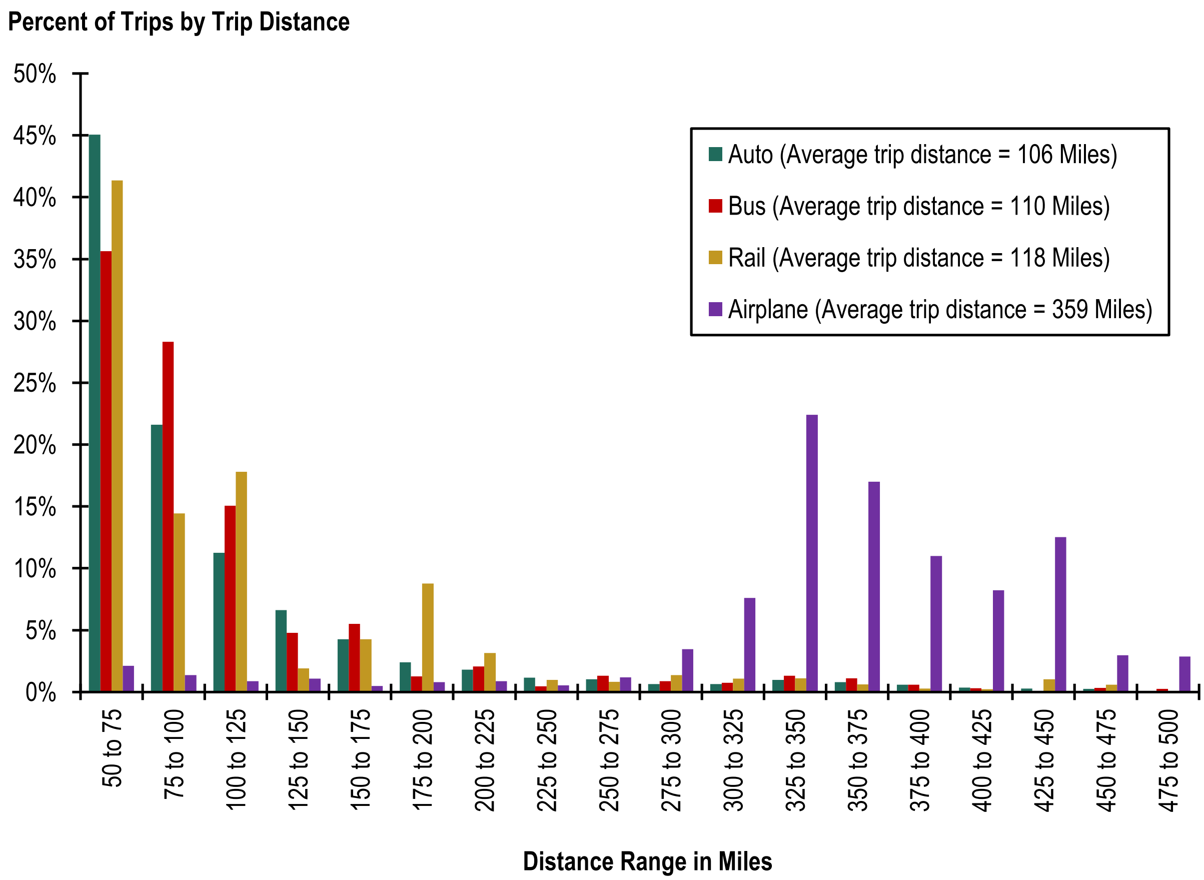


Source: Cambridge Systematics, Inc.

We estimate the average straight line distance between origin and destination locations for all long-distance trips within California to be 111 miles. Long-distance trips lengths vary by trip purpose with commute trips being the shortest (79 miles) and business trips being the longest (125 miles). Average trip distances for recreational and other trip purpose are 115 miles and 116 miles, respectively.

Trip Length Frequency by Main Travel Mode. Figure 2.3 shows the trip length frequency distributions by main travel mode within California. The shares of trips by auto and bus decrease rapidly and smoothly with increasing distance.

Figure 2.3 Long-Distance Trip Length Distribution by Mode



Source: Cambridge Systematics, Inc.

Shares of trips by rail also decrease rapidly, but less smoothly with increasing distance. The trip length distribution probably reflects two different types of rail travel: commuter rail within the San Francisco, Los Angeles, and San Diego metropolitan regions (for trips between 50 and 100 miles); and intercity rail travel between urban areas, such as Sacramento and San Francisco or San Diego and Los Angeles (for trips more than 100 miles). We should note that only 213 long-distance rail trips were reported in the CHTS Long-Distance Travel Log and expanded to represent long-distance rail travel in the State of California.

The trip length frequency distribution for air travel peaks between 300 and 450 miles, which reflects the travel distances between the major metropolitan areas in Northern and Southern California.

Trip Distribution by Geographic Region

We tabulated observed/expanded long-distance trips between six regions in California in Table 2.11. These data are expressed in "production to attraction" format, so that the directionality of travel between regions can be understood. The larger urbanized areas – SCAG and MTC – are both net producers of long-distance trips. This may seem counterintuitive, since regional travel models typically exhibit a net external-to-internal traffic flow across external cordons, especially in peak-commute periods. However, since the majority of long-distance travel is associated with recreational and other nonwork trip purposes, it is understandable that long-distance travel flow follows the patterns of recreational travel behavior (i.e., trips from population centers to recreation areas, such as the coastline or the mountains).

Table 2.11 Average Daily Long-Distance Trips between Regions

	To Region						
From Region	**SCAG**	**MTC**	**SANDAG**	**SACOG**	**San Joaquin Valley**	**Rest**	**Total**
SCAG	358,556	24,004	162,119	7,397	36,109	66,854	655,038
MTC	22,422	73,067	5,648	77,210	30,385	93,773	302,505
SANDAG	101,611	4,465	2,834	1,440	4,406	7,569	122,326
SACOG	4,624	41,346	1,039	11,138	6,577	23,723	88,448
San Joaquin Valley	52,039	51,037	3,434	19,389	56,306	49,904	232,109
Rest of State	15,315	46,762	1,645	20,195	11,354	40,030	135,302
Total	**554,567**	**240,682**	**176,720**	**136,769**	**145,137**	**281,853**	**1,535,728**

Source: Cambridge Systematics, Inc.

In Table 2.12, we tabulated the major flows between regions in California.

- More than one-half of long-distance travel produced by the geographically large SCAG region is destined for locations that also are within the SCAG region;
- The most popular source of interregional travel is between the adjacent Southern California urban areas (SCAG and SANDAG), and followed by the adjacent Northern California urban areas (MTC and SACOG); and
- The most popular source of interregional travel between nonadjacent regions is observed between the SCAG and MTC regions.

Table 2.12 Major Long-Distance Flows between Regions

Major Flows	Long-Distance Travel Log: Daily Long-Distance Trips	Total Productions	Percent of Total Productions on Major Flow
Intra-SCAG	358,556	655,038	55%
Intra-MTC	73,067	302,505	24%
Intra-SJV	56,306	232,109	24%
Intra-SACOG	11,138	88,448	13%
Intra-SANDAG	2,834	122,326	2%
SCAG to SANDAG	162,119	655,038	25%
SCAG to SJV	36,109	655,038	6%
SCAG to MTC	24,004	655,038	4%
SCAG to SACOG	7,397	655,038	1%
MTC to SACOG	77,210	302,505	26%
MTC to SJV	30,385	302,505	10%
MTC to SCAG	22,422	302,505	7%
SJV to MTC	51,037	232,109	22%
SJV to SCAG	52,039	232,109	22%
SJV to SACOG	19,389	232,109	8%
SACOG to MTC	41,346	88,448	47%
SACOG to SJV	6,577	88,448	7%
SACOG to SCAG	4,624	88,448	5%
SANDAG to SCAG	101,611	122,326	83%

Source: Cambridge Systematics, Inc.

Long-Distance Mode Shares

Mode Share by Trip Purpose. Table 2.13 summarizes long-distance mode shares by trip purpose. Auto is the dominant mode for all trip purposes, and bus mode shares are similar to those for rail for all trip purposes. The airplane mode is much more popular for business travel (over six percent) than for other trip purposes.

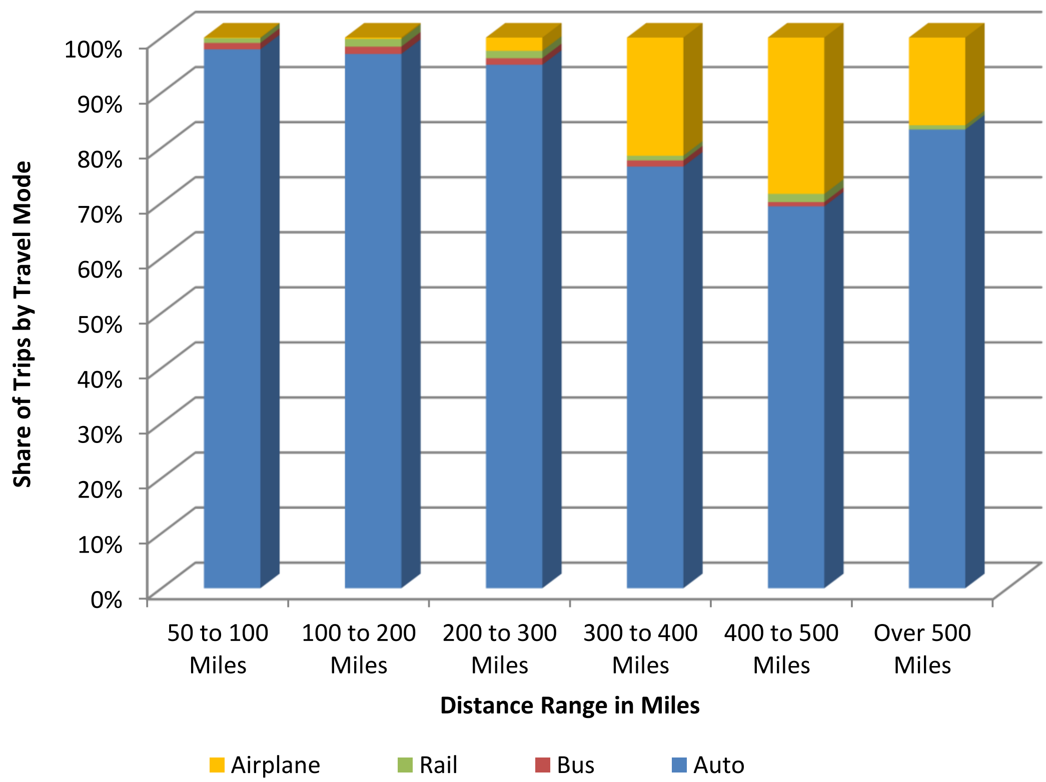
Table 2.13 Long-Distance Mode Shares by Trip Purpose

Trip Purpose	Main Travel Mode: Auto	Bus	Rail	Airplane
Business	91.50%	0.90%	1.40%	6.20%
Commute	97.90%	1.00%	0.90%	0.20%
Recreation	97.30%	1.00%	0.90%	0.90%
Other	96.10%	1.30%	1.10%	1.40%
All Purposes	**96.30%**	**1.10%**	**1.00%**	**1.50%**

Source: Cambridge Systematics, Inc.

Mode Share by Trip Length. Figure 2.4 summarizes long-distance mode shares by trip distance range. The figure also demonstrates the dominance of the auto mode for all distance ranges. However, the figure also shows that air travel captures significant portions of the travel market in the distance ranges of more than 300 miles.

Figure 2.4 Long-Distance Mode Shares by Trip Length



Source: Cambridge Systematics, Inc.

Airplane mode shares are significantly lower for this analysis, based on the 2012 CHTS Long-Distance Travel Log, than for the survey data previously documented for the 2011 Harris Survey and for the Version 1 Model. The 2012 CHTS Long-Distance Travel Log expanded and corrected shows an average airplane mode share of 27 percent for trips that are more than 300 miles, while the 2011 Harris Survey expanded shows an average airplane mode share of 34 percent for trips that are more than 300 miles.

Mode Share by Area Type. We tabulated main mode shares for long-distance travel according to the model's area type coded for both the production (home) and attraction end of long-distance trips (Table 2.14). We found that:

- There is a strong correlation between mode choice and area type at the production end, and that the correlation is even stronger at the attraction end;
- Airplane mode shares for long-distance travel are consistently higher for higher density area types; and
- Rail mode shares are significantly higher for long-distance travel to attractions in central business district (CBD) areas.

Table 2.14 Long-Distance Mode Shares by Area Type

	Main Travel Mode			
	Auto	**Bus**	**Rail**	**Airplane**
Area Type of Production TAZ				
Rural	97.20%	1.10%	0.50%	1.20%
Suburban	96.70%	0.70%	1.30%	1.30%
Urban	94.70%	1.40%	1.60%	2.30%
CBD Fringe	93.20%	1.80%	0.90%	4.20%
CBD	91.30%	3.00%	1.40%	4.40%
Total	96.10%	1.10%	1.00%	1.70%
Area Type of Attraction TAZ				
Rural	97.90%	1.00%	0.50%	0.50%
Suburban	96.80%	1.00%	0.80%	1.40%
Urban	96.30%	1.10%	0.60%	2.00%
CBD Fringe	92.80%	1.30%	1.60%	4.30%
CBD	88.60%	1.90%	4.60%	5.00%
Total	**96.10%**	**1.10%**	**1.00%**	**1.70%**

Source: Cambridge Systematics, Inc.

Mode Share by Group Travel. We tabulated the main travel mode shares for long-distance travel according to the group size data reported by survey respondents (Table 2.15). There is a strong correlation between mode choice and group travel. Auto mode is much more popular for group travel, given the ability to share costs for auto travel; whereas, similar cost savings are not typically available for group travel.

Table 2.15 Long-Distance Mode Shares by Group Status

	Main Travel Mode			
Group Type	**Auto**	**Bus**	**Rail**	**Airplane**
Alone	92.80%	1.80%	2.20%	3.20%
Group	97.80%	0.80%	0.40%	1.00%
Total	**96.10%**	**1.10%**	**1.00%**	**1.70%**

Source: Cambridge Systematics, Inc.

Comparison to Observed Ridership Data

This section presents comparisons of the expanded CHTS Long-Distance Recall survey data to observed ridership data for the rail and airplane travel modes.

Comparison with Rail Ridership Data. Amtrak provided city-to-city ridership data collected from ticket purchases, which we used to check the reasonableness of the rail ridership estimates from the expanded/corrected CHTS Long-Distance survey data. Using straight line distances between stations, we were able to eliminate short-distance trips (i.e., less than 50 miles.)

Table 2.16 compares the total ridership estimates from the Amtrak data, as well as Altamont Corridor Express (ACE) ridership between the San Joaquin Valley and MTC region to the rail ridership estimates from the expanded/corrected CHTS Long-Distance survey. The results were remarkably similar, especially considering how few observed records of rail travel were used to generate the CHTS estimates. For example, the estimate of long-distance rail travel between the SANDAG and SCAG regions was based on expanded/corrected from 44 survey records, and the resulting estimates are within one percent of each other.

Table 2.16 Comparison of Average Daily Long-Distance Rail Ridership Estimates

Regions	Route(s)	Total Riders	Percent Less Than 50 Miles	LD Riders	CSHTS LD Survey	Ratio
SANDAG-SCAG	Pacific Surfliner	4,345	8%	3,998	3,951	99%
SACOG-MTC	Capitol Corridor	3,641	11%	3,241	2,672	82%
SCAG-Central Coast	Pacific Surfliner	1,047	10%	942	1,634	173%
SJV-MTC	San Joaquin, ACE	2,418	40%	961	951	99%
MTC-SCAG	Coast Starlight	500[a]	0%	500[a]	600	120%
SANDAG-Central Coast	Pacific Surfliner	316	0%	316	444	141%
SJV-SACOG	San Joaquin	316	9%	287	336	117%
Total		**12,583**		**10,244**	**10,587**	**103%**

Source: Cambridge Systematics, Inc.

[a] Estimate. City-to-city data not available for this route.

Overall, the CHTS data are within three percent of matching the total volume of long-distance travel for the seven regional pairs tabulated in Table 2.16. This is evidence that, in spite of the small number of rail trips observed in the CHTS Long-Distance survey, the resulting expanded/corrected data provide a reasonably well-validated source of data.

Comparison with Airplane Passenger Data. A 10-percent sample of air passenger ticket data is available from the Bureau of Transportation Statistics, which is referred to as DB1B. This data source was analyzed by the Aviation System Consulting, LLC, which estimated that in 2009 (the most recent year available at the time) more than 12.5 million passengers traveled between major airports in Northern California (MTC and SACOG regions) and Southern California (SCAG and SANBAG regions). This equates to more than 34,000 air passengers per day, as displayed in Table 2.17. However, the air passenger estimates from the expanded/corrected CHTS Long-Distance survey identify only 19,000 air passengers per day, 55 percent of the total estimated from the 10 percent O&D Survey. CHTS data for all four regional markets between northern California and southern California are significantly less than the 10 percent O&D Survey data.

Table 2.17 Comparison of Daily Long-Distance Air Passenger Estimates

Regions	Passenger Count (2009)	2012 CSHTS Long-Distance Expanded	Ratio
MTC-SCAG	20,419	11,836	58%
MTC-SANDAG	6,495	4,201	65%
SACOG-SCAG	5,594	2,436	44%
SACOG-SANDAG	1,858	563	30%
Major Market Total	**34,366**	**19,035**	**55%**

Sources: Aviation System Consulting, LLC; and Cambridge Systematics, Inc.

Several hypotheses have been tested to try to explain this difference, but have yet to find an explanation that can account for the full magnitude of the difference. A portion of the difference can be explained by out-of-state visitors traveling within California, but this probably does not account for the full difference. As documented previously, the comparison of the CHTS Long-Distance survey to the Harris Survey completed in 2011 shows a difference between the two surveys in the number of long-distance air passengers on trips that are more than 300 miles in length. The 2012 CHTS Long-Distance Travel Log expanded and corrected shows an average airplane mode share of 27 percent for trips over 300 miles, while the 2011 Harris Survey expanded shows an average airplane mode share of 34 percent for trips over 300 miles.

We have not identified any systemic bias that would explain this difference. Our first inclination would be to assume that the differences result because the panels used for the Harris Survey were biased to oversample older and higher-income residents who are more likely to choose air travel for their main travel mode. However, the comparison of the expanded data to air passenger data collected in California indicates that the Harris Survey better reflects actual air passenger travel than the CHTS data. Since there is no definitive data source that confirms otherwise, we continue our analysis with the lower values for airplane travel from the 2012 CHTS for the time being.

2.3 2005 RP/SP SURVEY

The survey conducted to develop the Version 1 model included revealed-preference (RP) and stated-preference (SP) data from air, rail, and auto trip passengers. The RP portion of the survey asks about a trip actually made by the respondent, while the SP portion of the survey pivots off of the actual trip, but asks the respondent to consider hypothetical trip attributes and make hypothetical mode choices from which high-speed rail is one option.

In total, 3,172 surveys were conducted that composed of the following:

- 1,234 airline passenger intercept surveys;
- 430 rail passenger intercept and telephone surveys; and
- 1,508 auto trip telephone surveys.

Data Collection Process

Airline Passenger Surveys

Airline passenger surveys were conducted at six key airports throughout California:

- Surveys conducted inside terminals at boarding gates:
  - Sacramento
  - San Jose,
  - San Francisco; and
  - Fresno.
- Surveys conducted outside security areas:
  - Oakland, and
  - San Diego.

In the airports where surveying was done at the boarding gates, teams of surveyors were assigned to specific flights that were going to targeted destination airports in California. Potential respondents at Oakland and San Diego were approached and asked their travel destinations. California-bound travelers were administered the survey.

Mailback envelopes with postage paid were offered to respondents who did not complete the questionnaire in time to give it back to surveyor at the airport. Most surveys completed at the Sacramento, San Jose, San Francisco, and Fresno airports were collected at the airports from passengers who filled them out while waiting for their planes. Almost all of the surveys distributed at Oakland and San Diego were mailed back by respondents because passengers at these two airports did not have as much time to complete the survey outside the security area.

Rail Passenger Surveys

The rail passenger survey was conducted using two methodologies: 1) as an on-board, self-administered survey similar to the air passenger survey; and 2) as a telephone survey conducted among qualified users of existing rail services. On-board surveys were conducted on two commuter rail systems:

- ACE trains; and
- Metrolink trains.

Telephone surveys were conducted using a rider database from Amtrak that included riders from the following services:

- Capitol Corridor;
- Pacific Surfliner; and
- San Joaquin.

Rail passenger intercept (on-board) surveys were conducted on-board the ACE and Metrolink trains. Teams of surveyors were assigned to specific routes that were traveling across targeted regions served by this system. For example, on the Metrolink trains, routes that traveled between the San Diego and Los Angeles regions were targeted. Mailback envelopes with postage paid were offered to respondents who did not complete the questionnaire in time to give it back to surveyors on the train.

Auto Passenger Surveys

To capture the mode choice decisions of interregional travelers who have chosen to use autos, a random digit dial sample of household surveys was conducted among residents of the study area. A stratified sampling approach was utilized. This entailed dividing the State into the relevant regions and setting a targeted number of completes for households within each region. The final target quotas for the retrieval surveys were the following:

- A minimum of 120 responses from nine regions = more than 1,080;
- About 120 additional responses from some combination of the six smaller areas: Bakersfield, Tulare/Visalia, Fresno, Merced, Modesto/Stockton, and Sacramento; and
- About 250 additional responses from some combination of the three larger areas: San Diego, Los Angeles, and San Francisco Bay.

The final retrievals by region are as follows:

- San Diego (158);
- Los Angeles (243);
- Bakersfield (144);
- Tulare County/Visalia (98);
- Fresno (149);
- Merced (155);
- San Francisco Bay Area (283);
- Modesto/Stockton (145); and
- Sacramento (133).

Table 2.18 presents a summary of the air, rail, and auto passenger surveys collected. These are presented by trip purpose and mode.

Table 2.18 Air, Rail, and Auto Passenger Surveys by Mode and Purpose

Purpose	Auto	Air	Rail	Total
Business	172	543	64	779
Commute	9	12	123	144
Recreation/Other	1,059	283	91	1433
Total	**1,240**	**838**	**278**	**2,356**

Stated-Preference Portion

The stated-preference portion of the survey pivoted off of the actual trip taken by the respondent. Individuals were asked to envision a trip similar in most ways to this trip, but with some important differences. Those differences included modal attributes, which were presented to the respondents as part of the experiments. In addition, the high-speed rail alternative was always presented as a possible alternative. Each respondent completed four SP exercises.

SP Questionnaire

Each respondent was asked to complete four SP experiments; each of which had three or four modal choice alternatives to select from. For each experiment and each modal alternative, a list of attributes of that alternative was presented to the respondent. These attributes included travel time, travel cost, headway for nonauto modes, and reliability. Figure 2.5 shows an example of one SP experiment.

Figure 2.5 Example SP Experiment

Choice Exercise A

28. Your choices are...

TRAVEL BY CAR	TRAVEL BY AIR	TRAVEL BY HIGH SPEED RAIL
	Travel **to and from the airports** is the same as you described earlier in the survey (questions 15 - 19) You should arrive at the airport at least **1 hour** before your flight.	Travel **to and from the stations** is the same as you described earlier in the survey (questions 20 - 27) You should arrive at the station at least **10 min.** before your train
You travel whenever you would like	There is a flight **every 1 hour**	There is a train **every 1 hour**
The typical travel time in the car is **6 hrs 30 min** (not including stops for rest, food, etc.)	The scheduled travel time in the plane is **1 hr 20 min**	The scheduled travel time in the train is **2 hrs 40 min**
50% chance of arriving within **15 min.** of the typical time	80% of flights arrive within **15 min.** of schedule	85% of trains arrive within **5 min.** of schedule
The roundtrip fuel cost is **$70**	The roundtrip fare is **$320**	The roundtrip fare is **$140**
Travel by Car ☐	***Travel by Air*** ☐	***Travel by High Speed Rail*** ☐

Across the four SP experiments, the levels of each attribute were varied so that the respondent would consider several possible choice environments. The only thing that did not vary across experiments was the amount of time respondents was told to arrive early at the airport or train station. For air travel, it was indicated to respondents to arrive one hour prior to flight time; and for train travel, 10 minutes prior to train departure.

It also should be noted the difference in reliability measures between car/air travel and HSR travel in Figure 2.5 above. For the HSR alternative, the reliability measure was presented as the percentage of time trains will arrive within 5 minutes of schedule, while for all other modes, the reliability measure was presented as the percentage of time for being within 15 minutes of schedule.

Finally, for air, HSR, and CVR travel, the experiments always indicated that travel to and from the station/airport would be identical to the way the respondent described earlier in the survey. In cases where the individual chose air or CVR as their RP mode, this refers to the actual way in which the respondent traveled to the airport/station and the actual way the respondent intended to travel from the airport/station at egress. In addition, this information includes the travel time and travel cost for access and egress.

In cases where the individual did not choose the SP mode as their RP mode (which includes all instances of HSR), the survey asked the respondent to provide information about how the respondent believed they would access and egress the stations/airports. This included selecting the stations/airports they would use, the mode they believed they would use to access and egress, and the travel time and cost they believed they would encounter.

Nontrader Analysis

A common issue with SP surveys is the prevalence of nontraders. Nontraders are defined as individuals that select the same choice option in each SP experiment.

The main reason for examining the dataset in terms of traders and nontraders is simply to better understand the behaviors of each group. Since the mode choice models are reliant solely on the SP data to model HSR preferences, the SP data is quite important. This section examines the SP choice patterns of traders and nontraders, and offers a detailed analysis of drivers, passengers, and rail riders.

Transition Matrix

One key to understanding the behaviors observed in the SP data is simply looking at the choices of respondents. One key to understanding the behaviors observed in the SP data is simply looking at the choices of respondents for which a transition matrix can be useful. A transition matrix here refers to a table that shows the SP choice behaviors of respondents split out by what observed RP behavior was. That is, for existing car travelers, the transition matrix will show the SP choice behavior of those respondents, and similar for existing air and CVR travelers.

Table 2.19 shows the transition matrix of all traders in the dataset. The transition matrix shows the RP choice of the respondent on the left versus the SP choices of these individuals on the right. Keep in mind that all of these respondents are traders; meaning that across the four SP experiments, they selected at least two different modes of travel.

Table 2.19 SP Transition Matrix for Traders

	SP Distribution								
RP Mode	**Car**	**Air**	**HSR**	**CVR**	**Total**	**Car**	**Air**	**HSR**	**CVR**
Car	1,088	66	1365	175	674	40.4%	2.4%	50.7%	6.5%
Air	136	631	1147	0	497	7.1%	33.0%	59.9%	0.0%
CVR	120	11	451	298	224	13.6%	1.3%	51.3%	33.9%
Total	**1,344**	**708**	**2,963**	473	**1,395**	**24.5%**	**12.9%**	**54.0%**	**8.6%**

As shown in the table, the share of traders selecting their own RP mode varies from about 40 percent from car travelers to 33 percent for air and CVR travelers. HSR share ranges from about 50 to 60 percent.

Table 2.20 shows the transition matrix of all nontraders in the dataset. The transition matrix for nontraders is starkly different than that of traders. While car travelers are more likely to stay with their existing mode (52 percent compared to 40 percent for traders), air and CVR travelers are less likely to stay with their existing mode (15 percent and 22 percent for air and CVR compared with 33 percent and 34 percent for traders). Moreover, the HSR share is higher for nontraders than it is for traders.

Table 2.20 SP Transition Matrix for Nontraders

	SP Mode								
RP Mode	**Car**	**Air**	**HSR**	**CVR**	**Total**	**Car**	**Air**	**HSR**	**CVR**
Car	326	4	293	2	625	52.2%	0.6%	46.9%	0.3%
Air	7	62	349	0	418	1.7%	14.8%	83.5%	0.0%
CVR	2	0	85	25	112	1.8%	0.0%	75.9%	22.3%
Total	**335**	**66**	**727**	**27**	**1,155**	**29.0%**	**5.7%**	**62.9%**	**2.3%**

In all, one thing is quite clear from Tables 2.19 and 2.20 – there is a strong prevalence for choosing either the RP mode in the SP experiments or the new HSR mode.

Car versus HSR

This section examines the prevalence of individuals choosing the HSR mode when their RP mode was car. This is done by using travel time and cost differences and their effect on HSR share. Figure 2.6 shows the effect of travel time difference (measured between car and HSR) on the percentage of time HSR is the selected SP mode. Traders and nontraders are plotted separately. Keep in mind that the figure includes only those using car in the RP portion of the survey. Figure 2.7 plots the same thing, but using percentage differences in travel times rather than absolute differences.

Figure 2.6 Effect of Travel Time Difference on HSR Share among Car Travelers

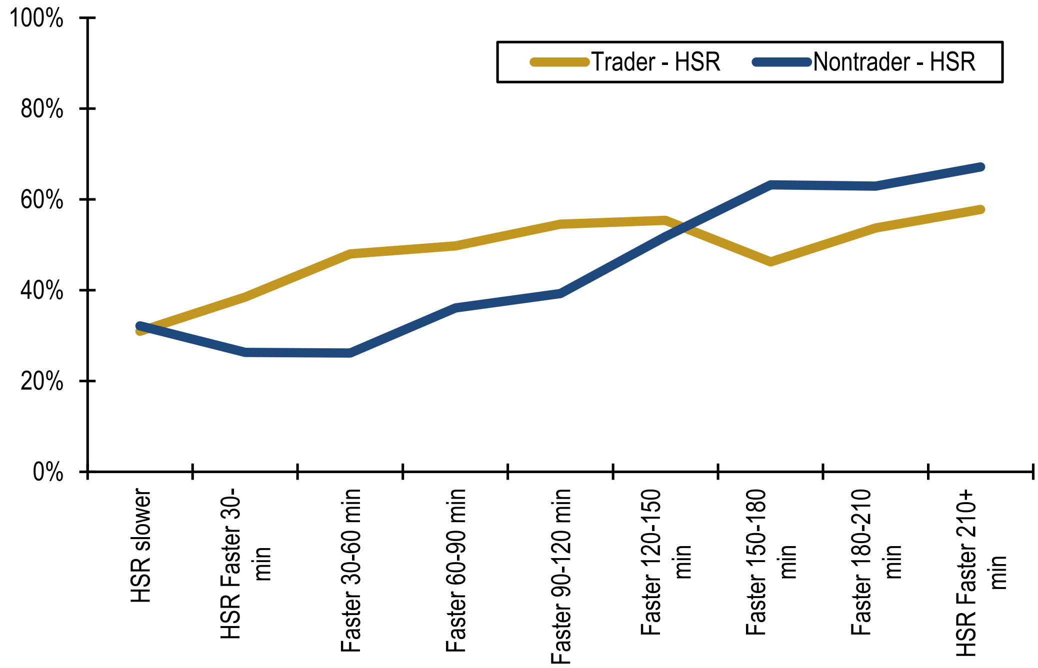
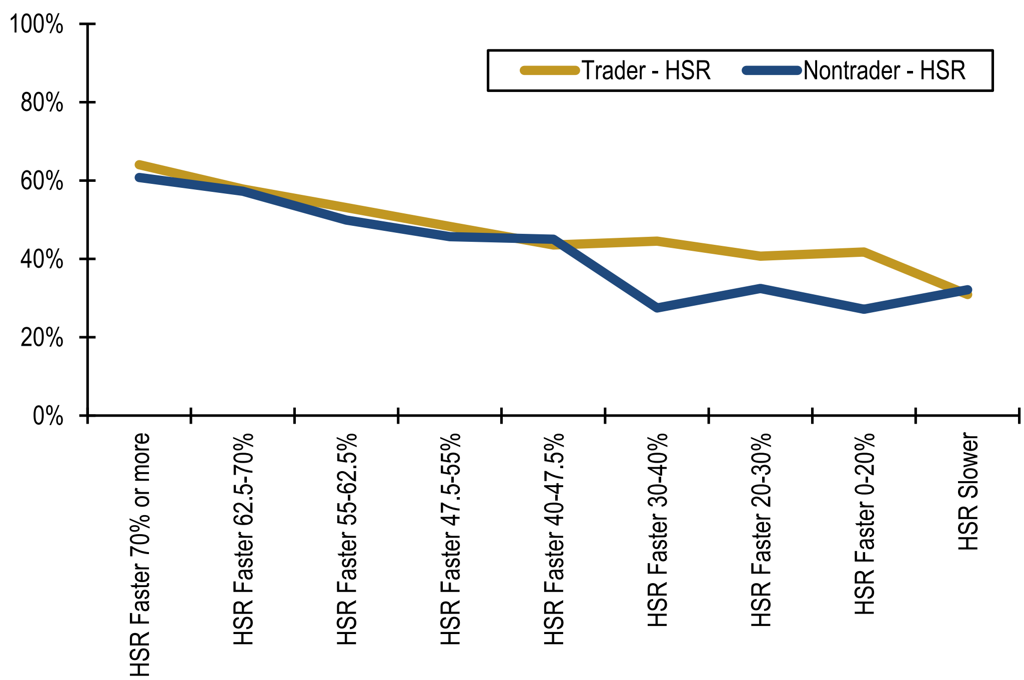


Figure 2.7 Effect of Percent Travel Time Difference on HSR Share among Car Travelers



As evidenced in the figures, the more competitive HSR travel times are, the higher share HSR attracts for both traders and nontraders.

Figure 2.8 shows the effect of cost differences on the percentage of time HSR is selected as the SP mode. Figure 2.9 shows the effect of percent cost differences on HSR share among car travelers.

Figure 2.8 Effect of Cost Difference on HSR Share among Car Travelers

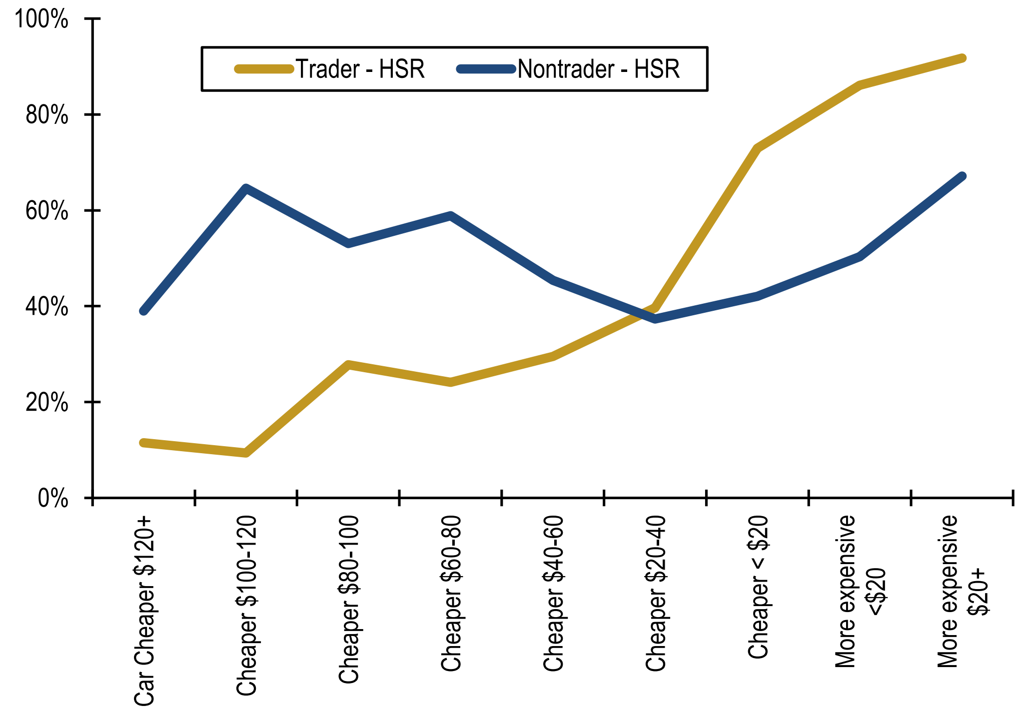
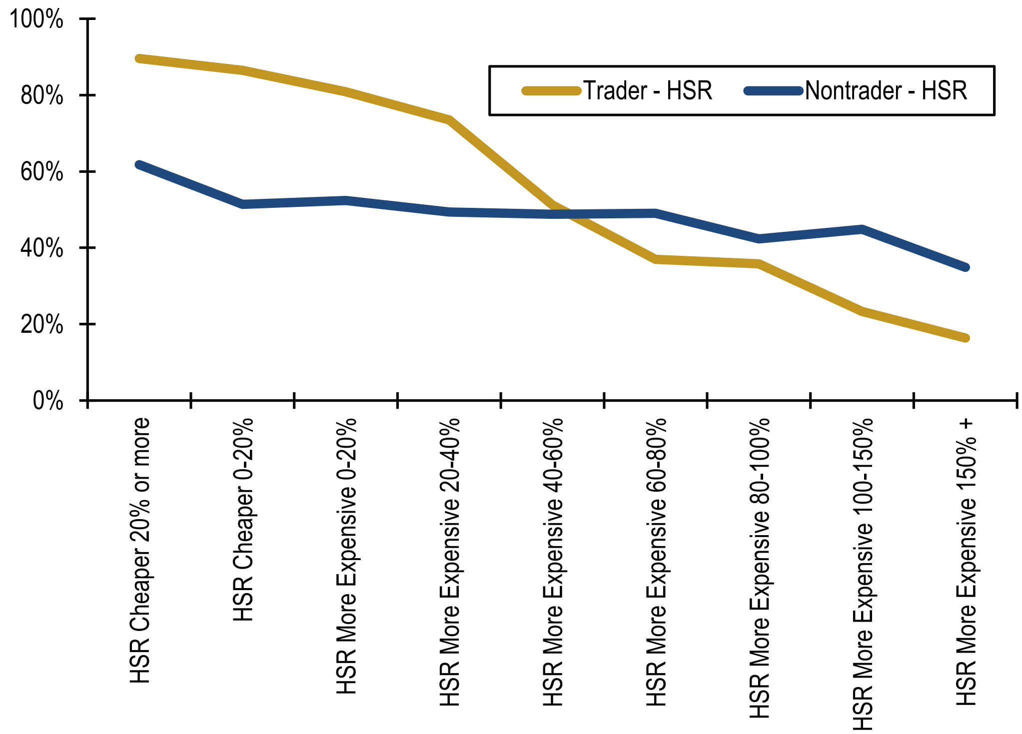


Figure 2.9 Effect of Percent Cost Difference on HSR Share among Car Travelers



Not surprisingly, traders again are quite rational with the share of HSR use increasing as HSR price becomes more competitive. However, unlike the travel time differences, the HSR share among nontraders does not show as strong of trends either way in Figure 2.8. This would seem to indicate that cost does not have much impact on HSR share among nontrader car travelers. On the other hand, Figure 2.9 does show a slight trend toward decline in HSR share among nontraders as HSR cost increases as a percent of car cost.

Air versus HSR

This section examines the prevalence of individuals choosing the HSR mode when their RP mode was air. Figure 2.10 shows the effect of travel time differences on HSR share among air travelers, both traders and nontraders. Figure 2.11 shows the similar plot, but using percent difference in travel time rather than absolute difference.

In both figures, the trends are similar. As HSR travel time becomes more competitive with air travel time, HSR share increases as expected.

Figure 2.10 Effect of Travel Time Difference on HSR Share among Air Travelers

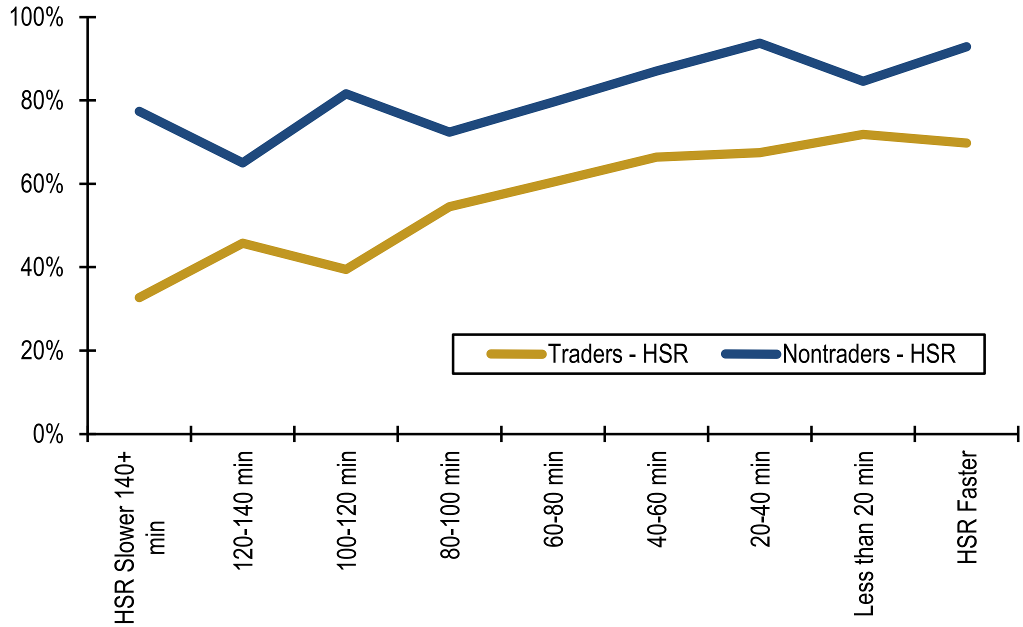


Figure 2.11 Effect of Percent Travel Time Difference on HSR Share among Air Travelers

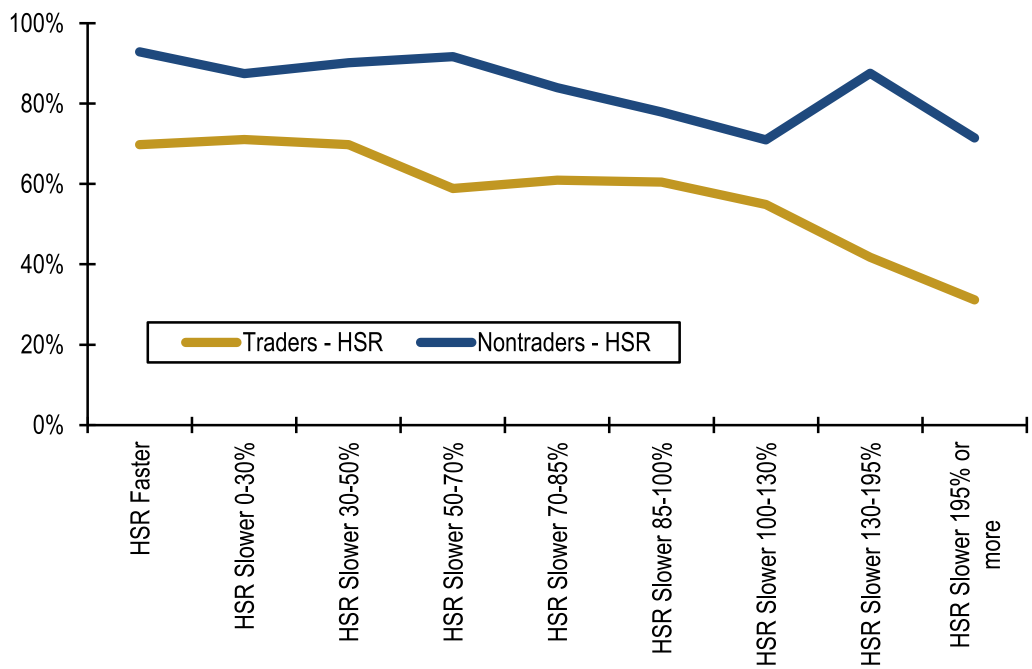


Figure 2.12 shows the effect of cost differences on the percentage of time HSR is selected as the SP mode among air travelers. Figure 2.13 shows the effect of percent cost differences on HSR share among air travelers.

Similar to car travelers, the cost differences show a fairly stark difference between traders and nontraders. While both groups of respondents appear to have rational behaviors in that HSR share increases as HSR costs become more competitive, traders show a great deal more sensitivity to cost than do nontraders.

Figure 2.12 Effect of Cost Difference on HSR Share among Air Travelers

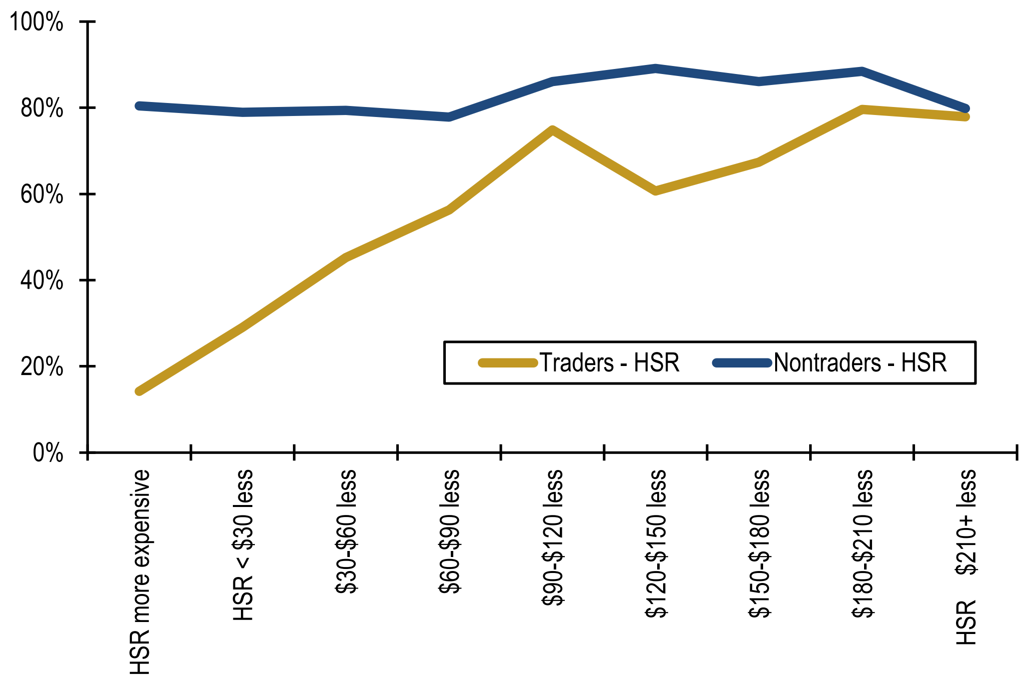
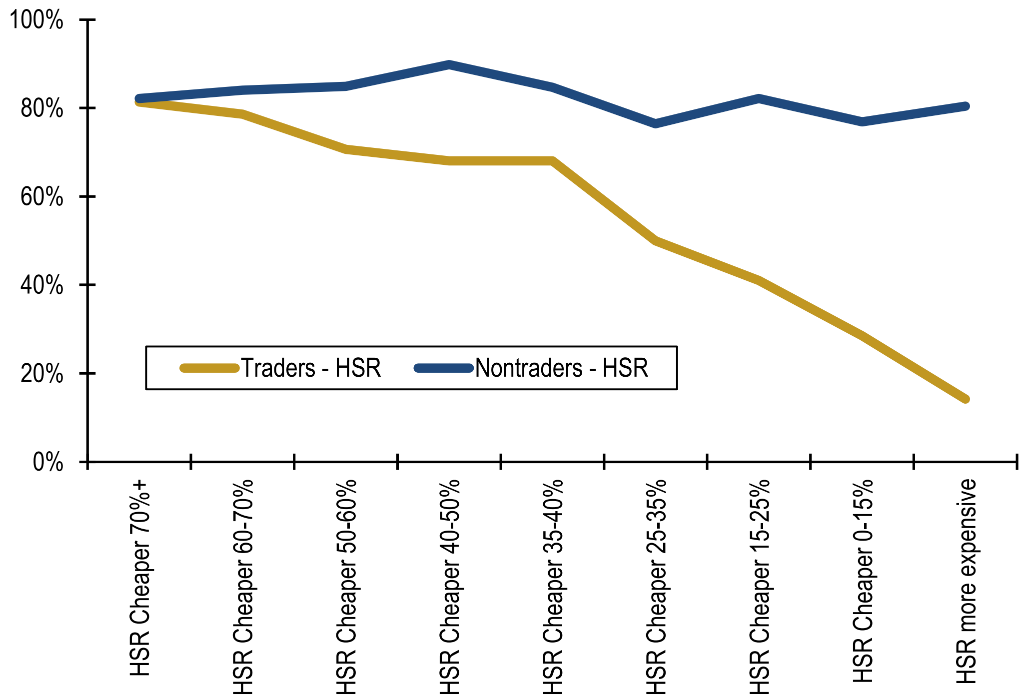


Figure 2.13 Effect of Percent Cost Difference on HSR Share among Air Travelers



CVR versus HSR

This section examines traders and nontraders among CVR travelers; again from the perspective of travel time and cost differences. Figure 2.14 shows the HSR share as travel time difference between HSR and CVR changes. Figure 2.15 shows the same thing, but using percent travel time differences.

Unlike the similar plots for car and air travelers, CVR travelers appear to be relatively unaffected by travel time differences. Both traders and nontraders show similar behaviors. Perhaps CVR travelers are relatively insensitive to travel time in the first place, which is perhaps why they travel on conventional rail. This theory makes more sense after seeing the cost differences curves below.

Figure 2.16 shows the effect of cost differences on the percentage of time HSR is selected as the SP mode, and Figure 2.17 shows the effect of percent cost differences on HSR share among CVR travelers.

In both cases, traders are more sensitive to costs than are nontraders, which was evidenced for car and air travelers as well. One interesting finding is how much traders are affected by cost differences among CVR users. While travel time differences had very little effect on HSR share among CVR users, cost differences have a profound effect, suggesting that CVR users may indeed be lower value of time travelers, who are much more sensitive to cost than travel time.

Figure 2.14 Effect of Travel Time Difference on HSR Share among CVR Travelers

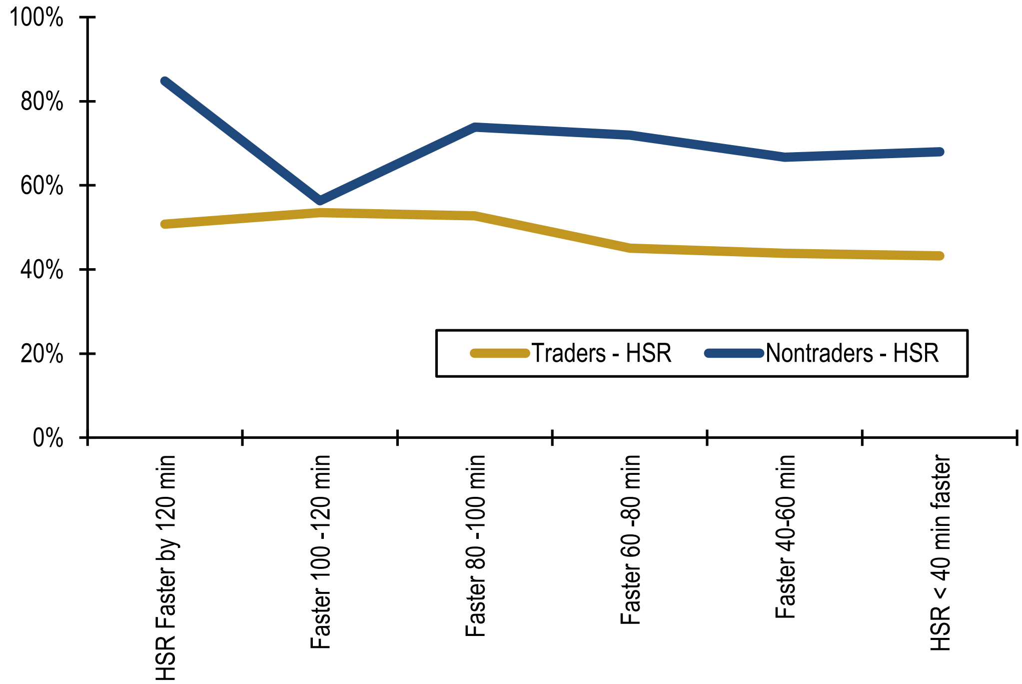


Figure 2.15 Effect of Percent Travel Time Difference on HSR Share among CVR Travelers

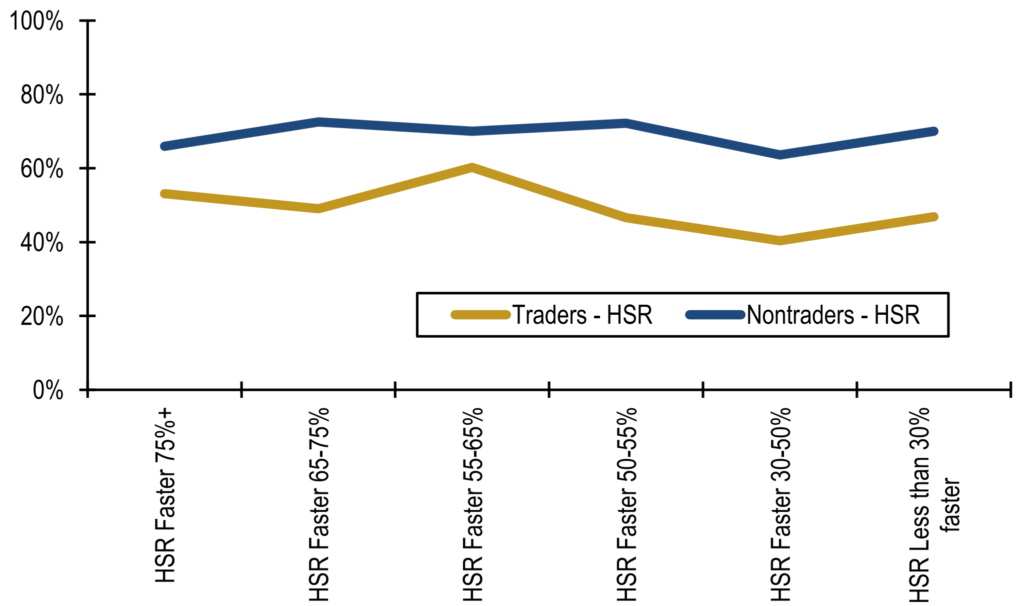


Figure 2.16 Effect of Cost Difference on HSR Share among CVR Travelers

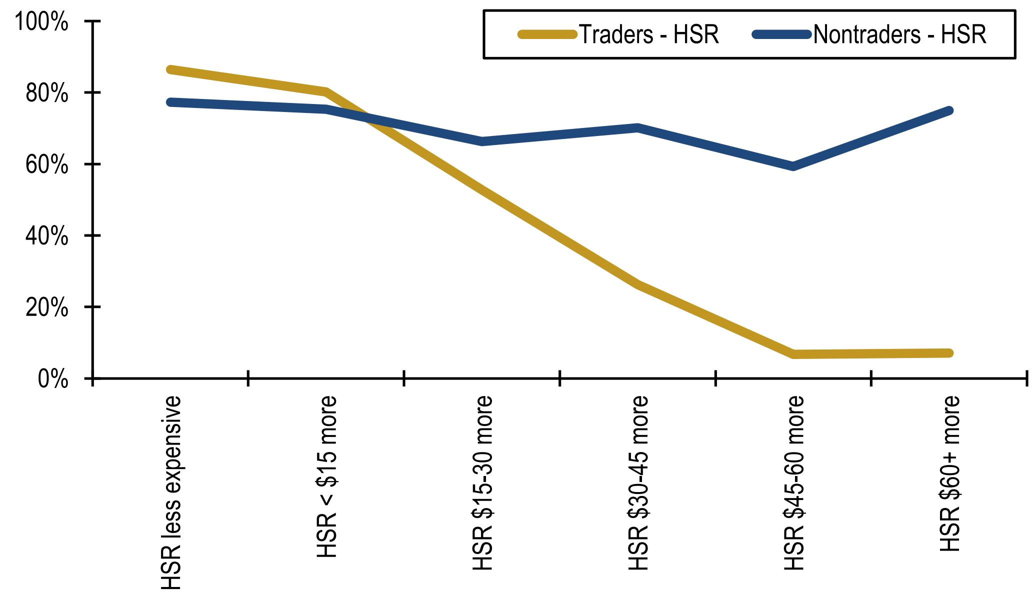
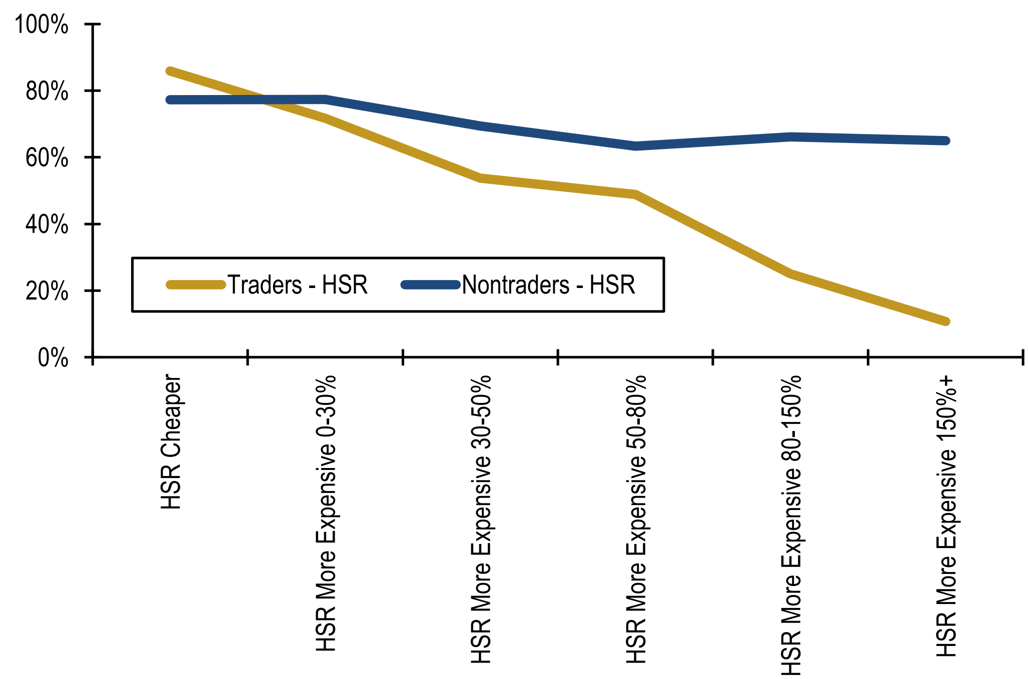


Figure 2.17 Effect of Percent Cost Difference on HSR Share among CVR Travelers



Summary

Overall, there appears to be some important differences between traders and nontraders in the RP/SP dataset. For some reason, nontraders have a slightly higher propensity for choosing HSR than nontraders overall, although the opposite is true for car travelers. However, there are some even more important distinctions among travel attributes.

While traders and nontraders seemed to be affected in similar ways by differences in travel times, traders were much more sensitive to travel costs than were nontraders. This trend was evidenced across all of the travelers, including car, air, and CVR travelers. Overall, the behaviors of traders in the dataset appear to be more rational than those of nontraders.

3.0 Long-Distance Model Input Data

3.1 Socioeconomic Data

The variables included in the input socioeconomic dataset are shown in Table 3.1. The employment and household data for year 2010 are consistent with the CSTDM. The data was converted from the CSTDM zone system to the CAHSR zone system. The methodology for developing the socioeconomic data within the CSTDM is described in the following sections.

Table 3.1 Socioeconomic Dataset Variables

Column Number	Column Header	Description
1	TAZ	CAHSR TAZ System: TAZs 123-6698 are internal TAZs
2	County	County number: California county code – numerically in alphabetical order
3	Region	Region number: CAHSR 14 regions
4	Prim_Sec	Primary and secondary employment: NAICS 11, 21, 23, 31-33
5	Whole	Wholesale trade employment NAICS 42
6	Tran_U	Transportation and utility employment NAICS 22, 48-49
7	Office	Office employment: NAICS 51-56, 92
8	Retail	Retail employment: NAICS 44-45
9	EduMed	Education and medical employment: NAICS 61-62
10	LeisHosp	Leisure and hospitality employment: NAICS 71-72
11	OthServ	Other service employment: NAICS 81
12	Military	Military employment, all industries
13	SpecGen	Special generators: 1 = Disneyland (TAZ 5796); 2 = Yosemite (TAZ 745)
14	Sqmile	Area of TAZ (square miles)
15	TotPop	Total population (includes group quarters)
16	TotHH	Total households (excludes group quarters)
17-115		Number of households segmented by HH size (0, 1, 2, 3, 4+); Number of HH Workers (0, 1, 2+); Income Group (Low: <$30K, Mid: $30K-$65K, High: >$65K (2005$)); Number of HH Vehicles (0, 1, 2+)

Overview of CSTDM Population Synthesizer

The CSTDM forecasts all personal travel made by every California resident, plus all commercial vehicle travel, made on a typical weekday in the fall/spring (when schools are in session). Included in the CSTDM framework is a synthetic population that represents every person and housing unit in California; it is based on sampling U.S. Census Public Use Microdata Sample (PUMS) five percent person and household data to match targets that can be derived from sources such as Summary File 3 (SF3), the American Community Survey (ACS), or other sources of data. The population synthesizer uses a large number of marginal targets representing categories, such as household sizes, housing types, household income groups, person age categories, auto ownership categories, employed workers by occupation category, and students by education level.

The population synthesizer, developed by HBA Specto, works by combining a trial population of households and altering it by switching new possible households in. If the match with the targets improves, the new household is kept. A detailed description of the algorithms used in this process is part of the detailed documentation of the population synthesizer (and can be found in *CSTDM09_Population_Final.pdf*). The population synthesizer is capable of handling multiple nested geographies, matching categorical totals or averages, and weighting possible targets. The weighting capability is useful if some targets are considered to be more important than others, or if the scales differ (such as with an average income category).

In general, synthesizing the population consists of four steps: 1) creating sample tables or individual household records; 2) creating target tables or control totals for available geographies; 3) testing the goodness of fit; and 4) aggregating the synthesized population by traffic analysis zones (TAZ). To enhance the accuracy of the population synthesis, population is synthesized by PUMA. Each PUMA has a sample table and a target table. The population synthesizer data from the CSTDM was then queried into the CHTS zone system by the 99 strata, as shown in Table 3.1.

The year 2010 synthesized population was based on the 2010 U.S. Census and ACS population and household statistics. Data directly from the U.S. Census was used without much modification, because these data are available in small geographies for the required time period. For example, the population total can be found by Census block for the year 2010. The block totals were then aggregated to the TAZ level, and the population synthesizer was run to cross-tabulate these totals.

Overview of CSTDM Employment Data

The CSTDM includes nine industry categories that are aggregated from 13 North American Industrial Classification System (NAICS) categories, as shown in Table 3.1. Three data sources were used together to develop the year 2010 industry categories by TAZ: California Employment Development Department (EDD), ACS Equal Employment Opportunity (EEO), and the Longitudinal Employment and Household Dynamics OntheMap (OTM).

California Employment Development Department (EDD)

The Division Labor Market Information (LMI) provides data to the public for the Employment Development Department (EDD) on California labor markets. The Quarterly Census of Employment and Wages (QCEW) releases data by industry, including the number of employees in each industry for each county. The QCEW is a program involving the Bureau of Labor Statistics of the U.S. Department of Labor and the State Employment Security Agencies (SESA). Employment and wage information for workers is tabulated for all employees covered by state unemployment insurance (UI) laws and Federal workers covered by the Unemployment Compensation for Federal Employees (UCFE) program. At the state and area levels, the QCEW program publishes employment and wage data down to the 6-digit NAICS industry level, if disclosure restrictions are met. In accordance with BLS policy, data provided to the Bureau in confidence are not published and are used only for specified statistical purposes. BLS withholds publication of UI-covered employment and wage data for any industry level when necessary to protect the identity of cooperating employers.

ACS Equal Employment Opportunity (EEO)

The ACS had recently published employment by industry. An advantage of this data is that it is derivative of a household survey and includes all types of employment, an advantage over QCEW employment by industry data. The recently released data included this information by place of work as well; whereas, it was previously related to household location and not the location of employment. This data also provides a more internally consistent definition of worker within the CSTDM because ACS data is used for workers on the population/household side.

A disadvantage of the ACS EEO data is that it does not publish data for counties with low numbers of employees for certain industries or occupations.

Longitudinal Employment and Household Dynamics (LEHD) OnTheMap (OTM)

OnTheMap data are a product of the LEHD project of the UC Census Bureau. The LEHD combines Federal and state administrative data on employers and employees with census data on where people live to provide information on home-to-work flows. OnTheMap data are synthesized using Unemployment Insurance Wage Records reported by employers and maintained by each state for the purpose of administering its unemployment insurance system. Each state assigns employer locations, but actual business locations are not used in the dataset to retain the confidentiality of the workforce. Instead, the underlying data are modeled to produce a synthetic dataset, which incorporates noise into the data to produce an accurate, but not exact, representation of employment.

The main advantage of OnTheMap data is the geographic units it uses (i.e., census blocks). The disadvantages of using this dataset include the fact that it is a synthetic dataset; and that several problems have been identified with the data, especially in the early years of publications (e.g., employees being linked to headquarters of companies rather than branch offices, which overestimates state workers in the State Capitol), but the industry has recognized the importance of the data and the improvements that have been made over the years, including the data from year 2010.

Methodology for Processing the Employment Data

To produce a reasonable estimation of 2010 employee counts by industry, we used the following method of combining the above data sources. Total employment for each county, as reported by the EDD data, provides county-level targets; and the distribution of employment by industry from the ACS EEO data was applied to those EDD totals. However, there were a few counties for which there was no ACS EEO employment by industry. For those counties (less than one percent of the statewide employment), the state industry distributions were assumed. The final step was to use OTM data to spatially distribute those county-level employment totals by industry to each CSTDM TAZ. A cross-walk was used to reassign the CSTDM TAZ totals to the CAHSR TAZ system.

We were able to evaluate each dataset using the most of the same industry categories based on NAICS. The single exception to this is for military jobs. While CTPP 2000 provides total employment for the military, the other datasets (EDD and OTM) do not. For this reason, the growth in military-employed persons by county between 2000 and 2010 was applied to the year 2000 military employment. It should be noted that military employment is not used in the CAHSR model.

Table 3.2 shows the specific breakdown of the types of employment included within each employment category used within the Version 2.0 model.

Table 3.2 Employment Categorization

NAICS Category	NAICS Code	CAHSR Model Category
Agriculture, Forestry, Fishing, Hunting	11	Primary Sector
Mining, Quarrying, Oil/Gas Extraction	21	
Construction	23	
Manufacturing	31-33	
Wholesale Trade	42	Wholesale Trade
Retail Trade	44-45	Retail Trade
Utilities	22	Transportation
Transportation and Warehousing	48-49	
Information	51	Office
Finance and Insurance	52	
Real Estate and Renting/Leasing	53	
Professional, Scientific, Technical Services	54	
Management of Companies and Enterprises	55	
Administrative/Support and Waste Management and Remediation Services	56	
Public Administration	92	
Educational Services	61	Education/Medical
Health Care and Social Assistance	62	
Arts, Entertainment, Recreation	71	Leisure/Hospitality
Accommodation and Food Services	72	
Other Services (except Public Administration)	81	Other Services

3.2 Highway Network

The representation of highway network supply is primarily determined by the level of detail in the highway network and the attributes associated with the roadway system, such as lanes, distances, speed, and capacity. For the Version 2.0 model, we began by building a 2010 Base Year Network, and then developing a Master Network that contained build-out information for year 2000 and forecast years from 2010 through 2040.

2010 Base Year Network Development and Quality Assurance (QA)/Quality Control (QC)

The 2010 Base Year Network for the CASHRA model is based on a 2008 Base Year statewide network provided by the University of California at Davis (UCD), prepared for the CSTDM. Because the HSR and UCD networks did not use the same projection, they could not be directly compared in Cube. The UCD network was stretched in GIS to best match the HSR network. The HSR network was updated to include new links (those not present in the original HSR network, especially in the SANDAG region) and attributes (number of lanes) of the links in both networks.

To update link speeds, the UCD networks' congested speeds were used where links matched the HSR network. An average of UCD's AM and PM peak single-occupant vehicle (SOV) skims was assumed for HSR peak, and an average of midday and off-peak SOV skims was assumed for HSR off-peak. For links not in the UCD network, but included in the original network, the original (2000) peak and off-peak congested speeds were used. For those links not included in the original network or the UCD network (of which there were very few), a regression equation, estimated using the 2000 congested speeds and link attributes, was applied.

It should be noted that the UCD networks were used as a guide for the network update and were not used to match their results.

During the network updating process, there were a number of difficulties encountered, and the following list provides a summary of the more significant ones:

- Networks in different projections;
- Different zonal systems, centroid locations, and centroid connectors made it difficult to compare their resultant highway skims (not an apples-to-apples comparison); and
- Different time periods were assumed in the networks and skims, making speeds a little odd to compare.

The following list provides a brief description of the QA/QC checks that were undertaken:

- Checked connectivity at region boundaries:
  - This was to correct any leftover issues from the original network, where various networks were stitched together; and
  - Some links that were not connected at the regional boundaries, but were really close and not easy to spot but were fixed to connect.
- Checked conversion of one-way/two-way links from GIS to Cube:
  - There were several links that were imported by Cube as one-way links instead of two-way links. These were manually fixed.
- Checked that all links had distances (greater than zero), area types, and facility types.

- Checked links that crossed each other, but did not intersect:
  - Needed to confirm whether they were legit (i.e., an overpass), or if a node needed to be added at the intersection to allow turning.
- Checked "dangling nodes" generated by GIS:
  - Needed to confirm whether they were legit (i.e., end of roadway) or were two links that were so close together that they appeared to be connected, but actually were not and were two "dangling nodes."
- Computed straight-line distances between zones to ensure that the skimmed distances were greater than the straight-line distances:
  - It should be noted that this was not always the case in the UCD network; there were some zone-to-zone distances that were shorter than the straight-line distances.
- Identified zone-to-zone skims that were very far off (when comparing the updated HSR-network auto skims and the UCD-network auto skims) and did manual reasonableness checks to ensure nothing was fundamentally wrong in the process.
  - For skims that were really far off, it was usually a product of the location of the centroid and its connectors in the "equivalent" zones.

Master Network Development

After the development of the base year network, UCD provided a master network, built for the CSTDM that includes project-level network coding by year. All of the projects and their associated build-out years were included in one single network file so that any future year network could be built easily. The projects included in the network were built using information from various California Regional Transportation Plans (RTP), Regional Transportation Improvement Programs (RTIP), Long-Range Transportation Plans (LRTP), and local travel demand models from April 2003 to October 2011. The project lists can be found in UCD's documentation, *CSTDM09 – California Statewide Travel Demand Model, Model Development, Network Preparation, and Coding*.

The first step to creating a master network for the CAHSR model was to create a correspondence between the CSTDM network and the CAHSR network, utilizing GIS and Cube software.

The CSTDM and CAHSR network layers had the same genesis, so large proportion of the A-B node information for each link was correctly associated between the two layers from the previous effort in updating the base year network. Where the A-B node information was not perfectly associated, at least one node was often correct.

Although Cube 6 offers a better integration with ArcGIS, the functionality is still limited. The networks were exported as node and link shapefiles. The projections of all files were corrected to NAD_1983_HARN_California_

Teale_Albers, which allowed the layers to be overlaid geospatially in ESRI ArcGIS.

The basic procedure for this exercise was to analyze how well links in the CAHSR layer within a certain functional class matched on their associated nodes to the links and nodes from the same functional class in the CSTDM link layer. Several functional classes were omitted from this analysis because their information on speed, etc., would be irrelevant to the transfer of data for the model. This included centroid connectors and transit access links, for example.

The following steps and joins were performed to merge the CSTDM A-B node information to the CAHSR link layer for each functional class.

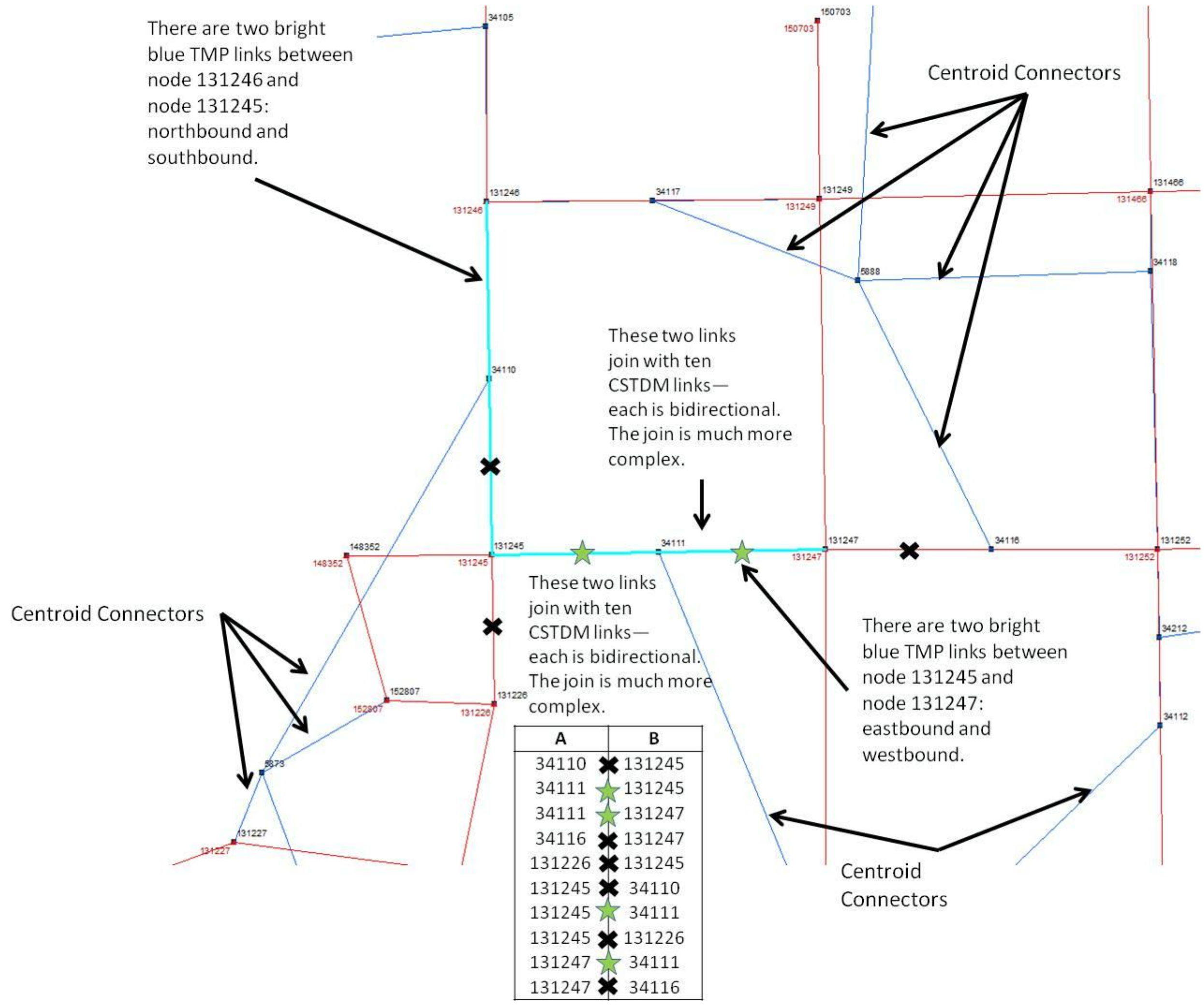
1. If both A and B were the same in both data sets.
2. If either A or B were the same in both data sets, the B or A from the next node on the joined link was returned to the data set.
3. In cases where the links were split by centroid connectors, it was sometimes difficult to determine which nodes were correct without a great deal of manual processing.
4. The data set was queried periodically to check whether data from one direction had been updated but not the other. This node information was then updated to the opposite fields to maintain directionality.
5. The remaining records were manually updated.

The corrected and update link data was reimported into the Cube network and checked for errors.

In the example shown in Figure 3.1, two pairs of CAHSR links are highlighted: 1) one pair is a northbound (NB)-southbound (SB) pair, and 2) the other is an eastbound (EB)-westbound (WB) pair. The links that the bright blue EB-WB links join with are noted as either a green star (desirable joins) or a black X (undesirable joins).

In these cases, a short script was written to daisy chain links together from the CSTDM layer that began and ended with the same A-B nodes from the CAHSR layer within the same functional class. When the total distances of these were approximately the same, as can be seen visually above, the A-B information was conflated.

Figure 3.1 Example of Merging the CSTDM Link Information onto the CAHSR Link Layer



With CSTDM node correspondences associated with each link of the CAHSR network, the attributes of the corresponding CSTDM link can be imported easily from the CSTDM master network or congested speeds from a CSTDM-loaded network.

For the remaining links that currently are not in the CAHSR network (i.e., new roadways in future year alternatives), they can be coded into the network, along with the CSTDM corresponding node numbers.

3.3 AIR OPERATING PLAN AND FARES

Level of service (LOS) assumptions for air was updated using the information provided by Aviation System Consulting, LLC (ASC)[11]. Since the latest year for which air headways and fares were provided was for 2009, these numbers were used and assumed to be the same for 2010. All fares were converted to year 2005 dollars for the model. The information provided by ASC did not contain headways and fares for several minor market corridors, for example, from Monterey Regional Airport to Los Angeles International Airport. Fares and headways for these corridors were calculated from the existing fares and headways from the Version 1 model using the following approach.

- Each corridor was first assigned a segment based on a crow-flying distance of either less than 280 miles or more than 280 miles.
- The average percentage changes in headways and fares were calculated from the existing ASC data and the previous air LOS data from the CAHSR model. These percentage changes were calculated for both the market segments of less than or more than 280 miles.
- The calculated percentage change was applied to the headways and fares obtained from the LOS file from the Version 1.0 model for the corridors for which ASC data was missing.

3.4 TRANSIT OPERATING PLANS AND FARES

The CAHSR base year model required transit service and fare information for year 2010. The general methodology for coding transit routing and frequency included keeping local bus service assumptions consistent with CAHSR Model Version 1 and updating rail services. Updating the local bus lines in the State would provide little change in the overall accessibility and path-building required for connections to and from long-distance transit services. For rail services, MPO modeling files were used for travel time and headway information. Where MPO modeling files were not obtained, on-line published schedules pulled from 2011 were used for network coding. Table 3.3 provides a list of all transit services that are included in the Version 2.0 model and details the data source used to obtain the operating plan and fares.

As shown in Table 3.3, the following transit services are considered CVR: ACE, Amtrak – Capitol Corridor, Amtrak – Pacific Surfliner, Amtrak – San Joaquin, Caltrain, Coaster, Metrolink, and Sprinter. These six lines are included as CVR in the main mode choice model. The other lines are only used as access and egress modes to HSR, air, and CVR.

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11 Aviation System Consulting, 2011, *Potential Airline Response to High-Speed Rail Service in California*, prepared for Cambridge Systematics, Inc.

Table 3.3 Transit Service Included in Model with Data Source for Year 2010 Operating Plan and Faers

Operator/Line	Transit Service	Data Source of Operating Plan	Data Source of Fare
AC Transit	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	MTC Year 2010 Model
ACE	CVR	MTC Year 2010 Model	On-line published fares – year 2011
AirBART	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	MTC Year 2010 Model
American Canyon	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	MTC Year 2010 Model
Amtrak- Capitol Corridor	CVR	On-line published schedule – Year 2011	On-line published fares – year 2011
Amtrak- Pacific Surfliner	CVR	SCAG Year 2008 Model	On-line published fares – year 2011
Amtrak- San Joaquin	CVR	On-line published schedule – Year 2011	On-line published fares – year 2011
Amtrak Shuttles	Bus	On-line published schedule – Year 2011	On-line published fares – year 2011
BART	Urban Rail	MTC Year 2010 Model	On-line published fares – year 2010
Benicia	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	MTC Year 2010 Model
Caltrain	CVR	MTC Year 2010 Model	On-line published fares – year 2010
Coaster	CVR	On-line published schedule – Year 2011	On-line published fares – year 2011
Contra Costa County	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	MTC Year 2010 Model
Dumbarton Express	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	MTC Year 2010 Model
Fairfield	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	MTC Year 2010 Model
Ferry	Ferry	MTC Year 2010 Model	On-line published fares – year 2010
Golden Gate Transit	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	MTC Year 2010 Model
Kern County Transit	Bus	CAHSR Model Version 1.0 Model – updated Year 2006	On-line published fares – year 2010
Metrolink	Urban Rail	SCAG Year 2008 Model	On-line published fares – year 2011
MetroRail	CVR	SCAG Year 2008 Model	On-line published fares – year 2010
Sacramento Regional Transit	Bus	CAHSR Model Version 1.0 Model – updated year 2006	On-line published fares – year 2010
Sacramento Regional Transit	Light-Rail Transit (LRT)	On-line published schedule – year 2011	On-line published fares – year 2010
SamTrans	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
	Express Bus	MTC Year 2010 Model	MTC Year 2010 Model
San Diego	Bus	SANDAG Transit Route File – year 2011	On-line published fares – year 2010
	LRT	SANDAG Transit Route File – year 2011	On-line published fares – year 2010
Santa Rosa	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
SCAG	Bus	CAHSR Model Version 1.0 Model – updated year 2006	On-line published fares – year 2010
SCVTA	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
	LRT	MTC Year 2010 Model	MTC Year 2010 Model

Operator/Line	Transit Service	Data Source of Operating Plan	Data Source of Fare
SFMTA	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
	Cable Cars	MTC Year 2010 Model	MTC Year 2010 Model
	Metro	MTC Year 2010 Model	MTC Year 2010 Model
Sonoma	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
Sprinter	CVR	On-line published schedule – Year 2011	On-line published fares – year 2010
Tri Delta	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
Union City	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
Vacaville	Bus	CAHSR Model Version 1.0 Model – updated year 2006	On-line published fares – year 2010
Vallejo	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
VINE	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
WestCat	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model
Wheels	Bus	CAHSR Model Version 1.0 Model – updated year 2006	MTC Year 2010 Model

3.5 Parking Costs and Availability

Auto Parking Costs

Auto parking costs for each TAZ were determined from parking costs obtained from SCAG, MTC, and SACOG MPOs. For areas that are beyond these three regions, parking costs were assumed to be the same as the previous version of the model. Parking costs from each MPO were translated to the CAHSR zone system as explained below.

- Parking costs obtained from MTC were available in the MTC zonal system, which exactly map on to CAHSR zonal system. Hence, parking costs were assigned to CAHSR TAZs in the MTC area based on the parking cost of the corresponding MTC zone.
- Parking costs obtained from SACOG were in the finer SACOG zonal system. Since SACOG TAZs are smaller, each CAHSRA zone had more than one SACOG zone. Parking costs of CAHSR TAZs within the SACOG area were extracted by taking the average parking cost based on the number of SACOG TAZs that fell within each CAHSR TAZ.
- Parking costs obtained from SCAG area were in the finer SCAG Tier 1 zonal system. Since SCAG TAZs were smaller than CAHSR TAZs, the average parking cost of each CAHSR TAZ was calculated by summing the product of area and parking cost of each SCAG TAZ and then dividing the resultant sum by the total area of all SCAG TAZs within each CAHSR TAZ. This area-

based averaging of parking cost ensured a more even distribution of parking costs in the CAHSR zonal system.

All parking costs were converted to year 2005 dollars based on consumer price index obtained from California Department of Industrial Relations.

Airport Parking Costs

Airport Parking costs were obtained from each airport's respective web site in January 2013. These costs were assumed for year 2010 and converted to year 2005 dollars. For airports with varying daily long-term parking costs, we calculated parking cost for the airport as the nonweighted average of all daily long-term parking cost options. One-half of the total parking cost is used, since the modeled trip is one-half of a round-trip. We assume two-day trips, so daily parking cost is input into the model. Table 3.4 shows the parking cost assumptions for each airport.

Table 3.4 Airport Daily Parking Cost

Airport	2005 Dollars
San Diego International Airport	$20
John Wayne Airport (Orange County)	$18
Long Beach Airport	$15
Los Angeles International Airport	$18
Ontario International Airport	$11
Bob Hope Airport (Burbank)	$16
Mineta San Jose International Airport	$19
San Francisco International Airport	$23
Oakland International Airport	$19
Sacramento International Airport	$12
Monterey Regional Airport	$15
Oxnard Airport	$7
Palm Springs International Airport	$10
Santa Barbara Airport	$12
Arcata/Eureka Airport	$9
Meadows Field Airport (Bakersfield)	$9
Fresno Yosemite International Airport	$8
Modesto City-County Airport	$0

Conventional Rail Parking Costs

Conventional rail parking costs were obtained from each station's respective web site in January 2013. These costs were assumed for year 2010 and converted to year 2005 dollars. Table 3.5 shows the parking cost assumptions for each station.

Table 3.5 Conventional Rail Daily Parking Cost

CVR Line	Parking Cost (2005$)
Caltrain	$3 at all stations
Metrolink	Los Angeles Union Station: $12
	Burbank Airport: $16
	6 other stations: $1-$3
	All other stations: Free
Capitol Corridor	Oakland: $11
	San Jose: $3
	Sacramento: $3
	All other stations: Free
ACE	San Jose: $3
	Santa Clara: $3
	All other stations: Free
San Joaquin Valley	Free at all stations
Pacific Surfliner	Free at all stations
Coaster	Free at all stations

Parking and Rental Car Availability

In addition to parking costs, parking and rental car availability were collected at each station and airports. All airports have parking and rental car facilities. There is no parking available at Metrolink's California State Los Angeles station and Pacific Surfliner's San Diego and Old Town station. Rental cars are only available at Los Angeles Union Station and Burbank Airport.

3.6 AUTO OPERATING COST

An estimate of 20 cents per mile, in 2005 dollars, was used for auto operating cost for the 2010 base year. That auto operating cost is based on a $2.80 per gallon average cost of fuel in year 2005 dollars,[12] an average fuel efficiency of 22 miles per gallon,[13] and a 7.5 cent per mile nonfuel cost.

[12] Equates to $3.22 per gallon in 2011 dollars. Source is U.S. Energy Information Administration estimate for California.

[13] Source: *California Motor Vehicle Stock, Travel, and Fuel Forecast, 2008*, Table 7, page 63.

4.0 Long-Distance Model Skims

4.1 Overview of Skims Required by Model

An important component of any travel demand model is an estimate of the LOS between each zone in the transportation network. The process to calculate these values is referred to as skims. There are four types of skims that the model uses:

Auto Mode:

1. **Auto skims,** representing congested highway average peak and off-peak travel time, distance, toll cost, parking cost at destination TAZs, and straight line distance between all TAZs.

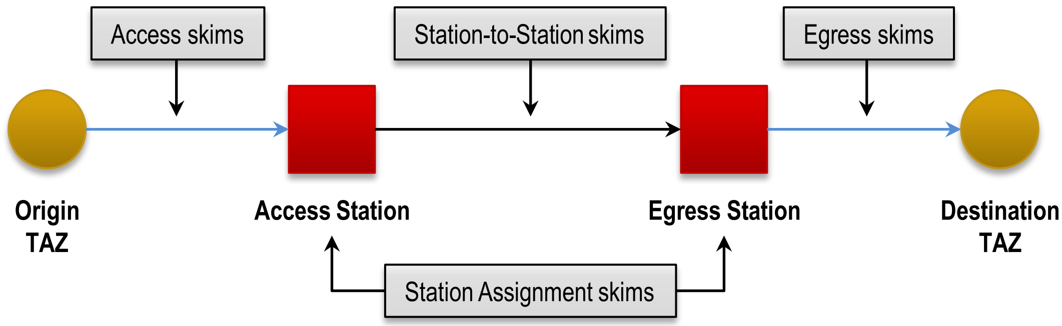
Public Modes (Air, CVR and HSR) (see Figure 4.1):

2. **Station-to-station**[14] **skims** that provide fares, in-vehicle travel time, headway, and reliability between station pairs for both peak and off-peak conditions.
3. **Station assignment skims** that identifies the access station and egress station utilized by each TAZ pair for both peak and off-peak conditions.
4. **Access and egress skims** between TAZs and airports, CVR stations, and HSR stations for both peak and off-peak conditions. The skims provide the auto highway distance, congested auto time, toll cost, transit fare, bus in-vehicle time, total transit in-vehicle time, out-of-vehicle time, drive access time, drive egress time, drive access distance, drive egress distance, parking cost at station (access only), parking availability (access only), and rental car availability (egress only).

Details of each of these types of skims are provided in the sections below.

[14] Note that stations also refer to airports in this discussion.

Figure 4.1 Skims for Public Modes (Air, CVR, and HSR)



4.2 AUTO SKIMS

Procedure for Developing Congested Skims

The congested travel times represent the sum of the congested travel times for the minimum time path obtained from the congested speeds on the CSTDM network, and terminal times. The congested speeds are a result of an equilibrium assignment output from the CSTDM model. We used the average of AM and PM peak skims for the SOV mode for the peak period, and an average of midday and off-peak SOV skims for the off-peak period. The peak and off-peak travel times were then averaged, using a weighted average approach, to obtain average daily travel times.

Auto terminal times represent the average time to access one's vehicle at each end of the trip and are added to the congested travel time to get the total congested travel time skim. They are based on the area type of each of the trip ends (see Table 4.1). The terminal time assumptions are the same as the Version 1 model.

Table 4.1 Auto Terminal Times
Minutes

Area Type	Origin	Destination
CBD	2	5
Urban	1	2
Small urban	1	1
Suburban	1	1
Rural	1	1

A definition of the area types is provided in Table 4.2. "People per square mile" was taken to be the maximum of either the residential or employment population of the zone.

Table 4.2 Area Type Definitions

Area Type	Area Type Number	People per Square Mile
CBD	1	More than 20,000
Urban	2	10,001-20,000
Small urban	3	6,001-10,000
Suburban	4	1,001-6,000
Rural	5	1,000 or less

Intrazonal travel times were calculated as a portion of the average travel time to the three closest zones. The portion varies with the area type of the zone: two-thirds for the CBD; one-half for urban areas, one-third for small urban and suburban areas, and one-half for rural areas. This methodology is consistent with the Version 1 model.

We employed several checks to ensure accuracy and reasonableness of the congested travel times. The first check was to map travel time from selected airports to assess spatial reasonableness. Figure 4.2 shows travel time to the San Francisco, Sacramento, Fresno, and Los Angeles airports from all TAZs in California. These maps indicate that, as distance increases from the airport, travel time increases.

Another check mapped out average speed to selected airports to ensure that travel time was reasonable in relation to the distance traveled and the location. Figure 4.3 shows average travel speed to the San Francisco, Sacramento, Los Angeles, and San Diego airports. Travel speed is lowest the closer the origin is to the airport, indicating the lower percentage of travel that is on highways for these trips. As distance increases, average speed increases, indicating the higher percentage of the trip occurring on highways.

The final check compared the travel times from the highway skims to the stated travel time of survey respondents who reported driving to and from an airport or CVR station in the year 2005 RP survey data. After correcting for survey data entry errors (such as switching the access and egress stations), the highway skim travel times were appended to the survey data. For the intercept surveys that reported categorical travel times (i.e., 10 = 0 to 15 minutes, 20 = 15 to 30 minutes, 45 = 30 to 60 minutes, 75 = 60 to 90 minutes, 105 = 90 to 120 minutes, 120 = more than two hours), the difference between the skimmed travel time and stated travel time was computed as the minimum difference within each travel time category (i.e., if the stated travel time was 10 minutes and the skimmed travel time was 17 minutes, the difference in travel time was reported as 2 minutes, which is 15 minutes subtracted from 17 minutes). For the telephone surveys that reported actual stated travel time, the difference was computed directly by subtracting the stated travel time from the highway skimmed travel time.

Figure 4.2 Travel Time to Select Airports

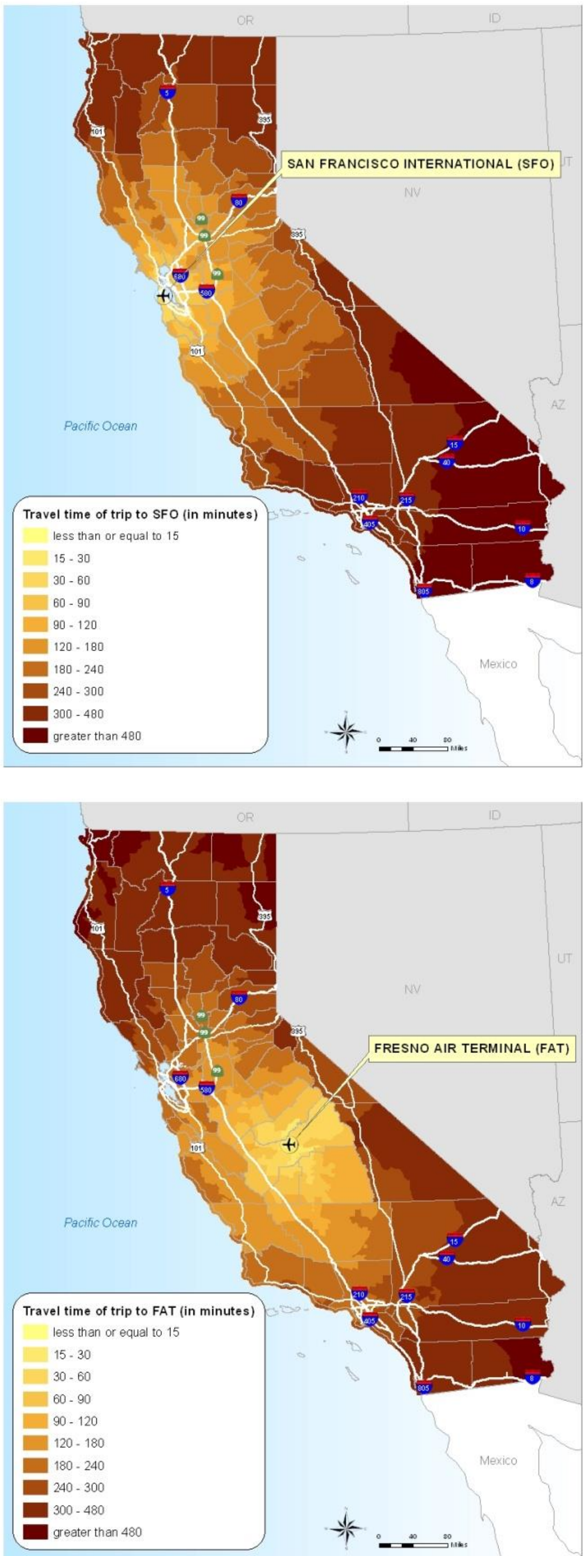


Figure 4.3 Average Speed to Select Airports

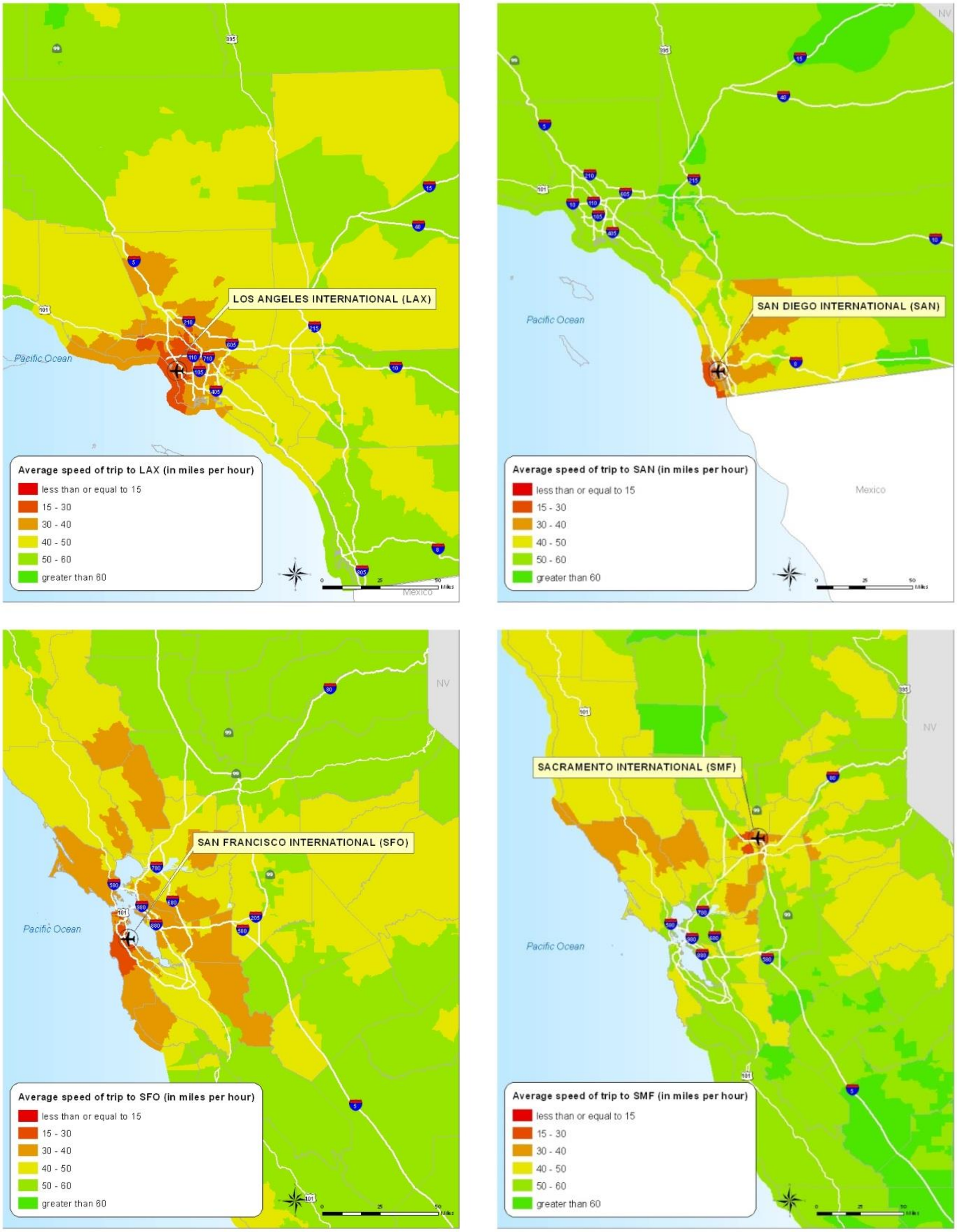


Table 4.3 shows the comparison of the highway skim travel time to the stated travel time from the surveys. The highway skims match very well to the stated travel times. Close to 79 percent of the surveys have skimmed and stated travel times within 10 minutes of each other. Almost 88 percent of the surveys have skimmed and stated travel times within 30 minutes of each other. Select TAZ pairs from the surveys with stated and skimmed travel times more than 45 minutes apart were spot checked to ensure that the highway skims were accurate. In all of these cases, the stated travel times were erroneously reported as too high or too low.

Table 4.3 Highway Skim Travel Time in Comparison to RP Survey Stated Travel Time

Highway Skim in Relation to Stated Travel Time	Percentage
Greater than 45 minutes lower	8.2%
30 to 45 minutes lower	1.6%
10 to 30 minutes lower	8.9%
Less than 10 minutes lower	66.5%
Less than 10 minutes higher	12.4%
10 to 30 minutes higher	0.0%
30 to 45 minutes higher	0.0%
Greater than 45 minutes higher	2.3%

Toll Cost

Toll costs were imported from networks developed for the CSTDM and documented in *CSTDM09 – California Statewide Travel Demand Model, Model Development, Network Preparation, and Coding*; and converted into year 2005 dollars (in cents). Tolled and general purpose lanes are coded separately in the CSTDM network. Tolls are input to the model by time of day and by auto occupancy. Tolls corresponding to SOV were used. Peak and off-peak tolls were averaged where costs differed.

Toll costs to selected airports were mapped to ensure that toll costs were reasonable in relation to trip origin location. Figure 4.4 shows total toll costs to the San Francisco, Sacramento, Los Angeles, and San Diego airports, respectively. Tolls included in the updated network comprise congestion pricing on I-15 north of San Diego and SR 91, as well as tolls on a number of other facilities across the State, as shown in Figures 4.5 and 4.6.

Figure 4.4 Total Toll Cost to Select Airports

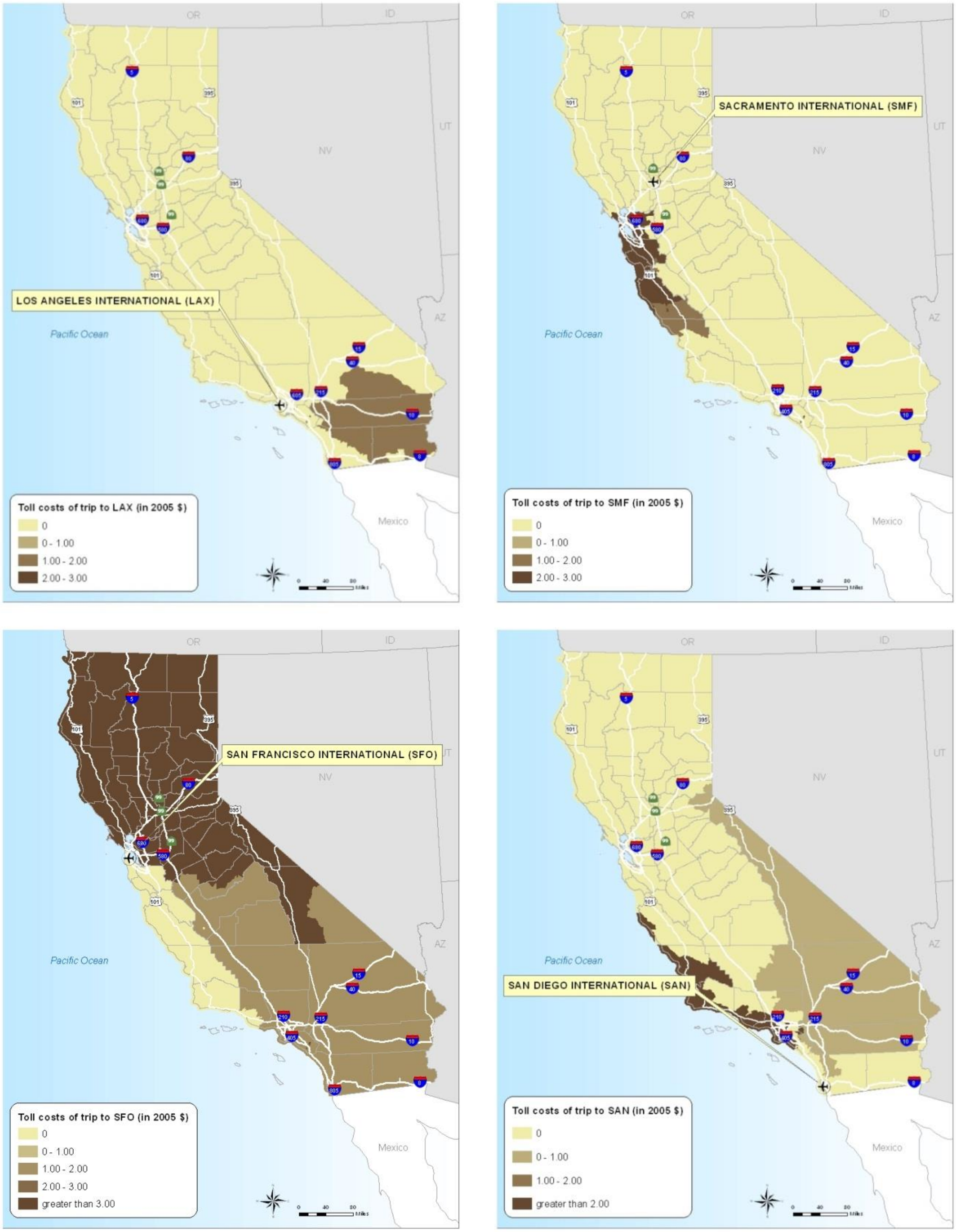


Figure 4.5 Toll Locations in Bay Area

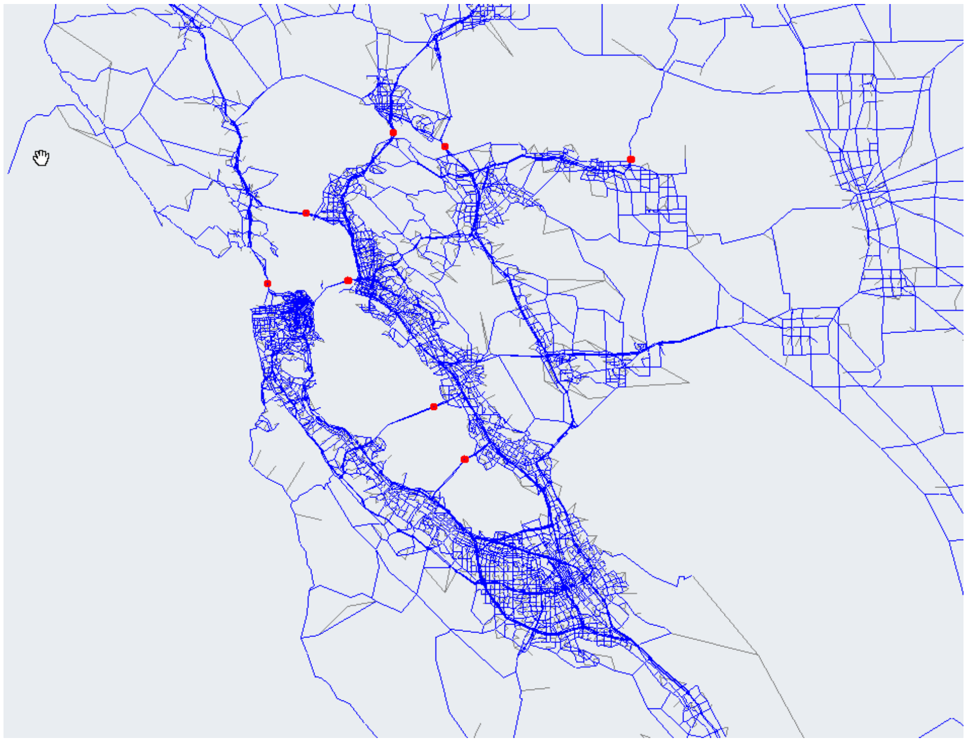
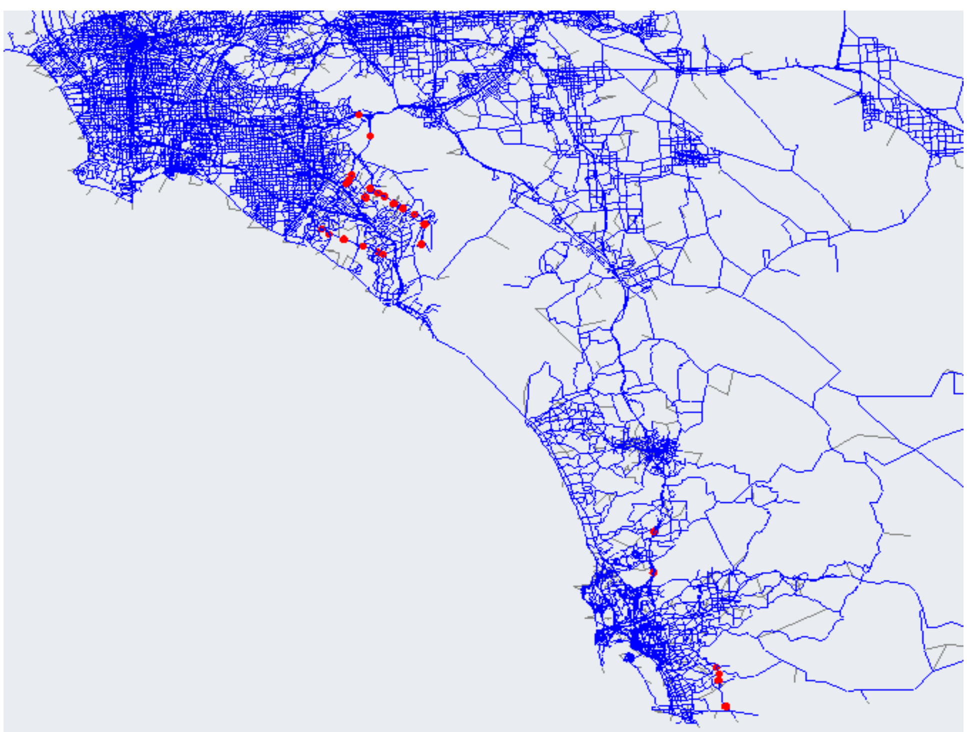


Figure 4.6 Toll Locations in Southern California



4.3 STATION-TO-STATION SKIMS

The station-to-station skims for air, CVR, and HSR include fare, in-vehicle travel time, headway, and reliability between station pairs. The air station-to-station fares, in-vehicle travel time, and headway are computed outside of the Cube skimming process, as described in Section 3.3. The Cube skimming process calculates the optimal path between station pairs using the given LOS information and generalized cost function that converts all travel characteristics to the same unit of measure. Table 4.4 provides the assumptions for developing the generalized cost function that is used for calculating the best path between stations for CVR and HSR.

Table 4.4 CAHSRA Station-to-Station Skim Specifications and Assumptions to Develop Generalized Cost Function

	CVR		HSR	
	Peak	**Off-Peak**	**Peak**	**Off-Peak**
Cube skimming process	Best Path	Best Path	Best Path	Best Path
Fares considered in path evaluation	No	No	No	No
Maximum transfers	Unlimited	Unlimited	Unlimited	Unlimited
Initial wait time	20% of headway	20% of headway	20% of headway	20% of headway
Transfer wait time	Half of headway	Half of headway	Half of headway	Half of headway
Transfer penalty	5 minutes	5 minutes	5 minutes	5 minutes
Transfer penalty time weight in relation to IVTT	2.5	2	2.5	2.5

Reliability also is added onto the air, CVR, and HSR skims. Reliability is defined as the percentage of scheduled trips arriving within 15 minutes of the scheduled arrival time. For flights, the Bureau of Transportation Statistics (BTS) provides information on the percentage of air trips that arrive within 15 minutes of their scheduled arrival time into each airport, as shown in Table 4.5 for year 2010. Reliability information for CVR was obtained from CVR operator web sites and documentation and from the Version 1.0 model documentation. The percentage of trains arriving with 15 minutes of scheduled arrival time for each CVR operator, for year 2010, is shown in Table 4.6.

If the journey requires transferring from one flight to another or from one train to another, the reliability of each leg is multiplied together. Thus, reliability reflects the number of transfers in the path. The more you have to transfer, the greater the likelihood you will end up delayed.

Table 4.5 Percentage of Air Trips Arriving within 15 Minutes of Scheduled Arrival Time to each Airport, Year 2010

Airport	Percentage of Trips Arriving within 15 Minutes of Scheduled Time
San Diego International Airport	82%
John Wayne Airport (Orange County)	84%
Long Beach Airport	83%
Los Angeles International Airport	82%
Ontario International Airport	82%
Bob Hope Airport (Burbank)	82%
Mineta San Jose International Airport	82%
San Francisco International Airport	71%
Oakland International Airport	81%
Sacramento International Airport	80%
Monterey Regional Airport	77%
Oxnard Airport	88%
Palm Springs International Airport	82%
Santa Barbara Airport	83%
Arcata/Eureka Airport	64%
Meadows Field Airport (Bakersfield)	81%
Fresno Yosemite International Airport	80%
Modesto City-County Airport	61%

Table 4.6 Percentage of CVR Trips Arriving within 15 Minutes of Scheduled Arrival Time by Operator, Year 2010

Operator	Percentage of Trips Arriving within 15 Minutes of Scheduled Time
Caltrain	95%
Capitol Corridor	86%
ACE	94%
Amtrak Shuttles	83%
San Joaquin	77%
Metrolink	95%
Coaster	95%
Pacific Surfliner	95%

4.4 STATION ASSIGNMENT SKIMS

The station assignment skims provides the access station and egress station utilized by each TAZ pair for air, HSR, and CVR. The skims consider only drive access and egress to the station, so only the highway network and the line files for each respective mode are included as input into the skims. The Cube skimming process calculates the optimal path between TAZs using the congested highway network, line file corresponding to each skim mode, and a generalized cost function. Table 4.7 provides the assumptions for developing the generalized cost function that is used for calculating the best path between stations. Once the best path is determined, only the access station and egress station for each TAZ pairs are outputted in the skim matrices.

Table 4.7 CAHSRA Station Assignment Skim Specifications and Assumptions to Develop Generalized Cost Function

	CVR		Air		HSR	
	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
Cube Skimming Process	Best Path	Best Path	Best Path	Best Path	Best Path	Best Path
Fares considered in Path Evaluation	No	No	No	No	No	No
Maximum Drive Distance to Other Transit Lines	Varies from 0 to 6 miles	Varies from 0 to 6 miles	Varies from 0 to 6 miles	Varies from 0 to 6 miles	Varies from 0 to 6 miles	Varies from 0 to 6 miles
Maximum Transfers	4	4	4	4	4	4
Initial Wait Time	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes
Transfer Wait Time	1/2 headway	1/2 headway	1/2 headway	1/2 headway	1/2 headway	1/2 headway
Value of Time	$45	$15	$45	$15	$45	$15
Boarding Penalty	None	None	None	None	None	None
Transfer Penalty	5 minutes	5 minutes	5 minutes	5 minutes	5 minutes	5 minutes
Walk Time Weight in Relation to IVTT	2.5	2	2.5	2	2.5	2
Drive Time Weight in Relation to IVTT	2.5	2	2.5	2	2.5	2
Transfer Time Weight in Relation to IVTT	2.5	2	2.5	2	2.5	2
Transfer Penalty Time Weight in Relation to IVTT	2.5	2	2.5	2	2.5	2

4.5 ACCESS-EGRESS SKIMS

The Access/Egress Mode Choice Model has six modal options: drive and park, rental car, drive and drop-off/pick-up, taxi, transit, and walk. The LOS variables were obtained from the sources shown in Table 4.8. Table 4.9 reflects the final set of specifications and assumptions used as input into the generalized cost function used to build the transit skims.

Table 4.8 Source of Travel Time and Cost Variables for CAHSRA Access/ Egress Mode Choice Model

	In-Vehicle Travel Time	Out-of-Vehicle Travel Time	Cost
Drive and Park	Travel time from highway skims	N/A	• Toll cost from highway skims • Network distance x auto operating cost • Parking cost at Station
Rental Car	Travel time from highway skims	N/A	• Toll cost from highway skims • Network distance x auto operating cost
Drive and Drop-off/ Pick-up	Travel time from highway skims	N/A	• Toll cost from highway skims • Network distance x auto operating cost
Taxi	Travel time from highway skims	N/A	• Network distance x taxi cost per mile
Transit	In-vehicle travel time from transit skims	Walk/Drive Access Time + Initial Wait Time + Transfer Wait Time + Transfer Time + Walk/Drive Egress Time	• Fares from transit skims • Drive access+egress distance x auto operating cost
Walk	N/A	Network distance x 3 mph	N/A

Table 4.9 Access/Egress Transit Skim Specifications and Assumptions for Use in Generalized Cost Function

	CVR		Air		HSR	
	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
Cube skimming process	Multirouting	Multirouting	Multirouting	Multirouting	Multirouting	Multirouting
Fares considered in path evaluation	Yes	Yes	Yes	Yes	Yes	Yes
CVR transit lines	Not included	Not included	Included	Included	Included	Included
Amtrak shuttle bus treatment	Transfers allowed to/from any mode	Transfers allowed to/from any mode	Transfers allowed to/from CVR	Transfers allowed to/from CVR	Transfers allowed to/from CVR	Transfers allowed to/from CVR
Maximum drive distance to CVR	N/A	N/A	200 miles	200 miles	200 miles	200 miles
Maximum drive distance to other transit lines	Varies from 0 to 6 miles	Varies from 0 to 6 miles	Varies from 0 to 6 miles	Varies from 0 to 6 miles	Varies from 0 to 6 miles	Varies from 0 to 6 miles
Maximum transfers	4	4	4	4	4	4
Initial wait time	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes	1/2 headway up to 15 minutes
Transfer wait time	1/2 headway	1/2 headway	1/2 headway	1/2 headway	1/2 headway	1/2 headway
Value of time	$45	$15	$45	$15	$45	$15
Boarding penalty	None	None	None	None	None	None
Transfer penalty	5 minutes	5 minutes	5 minutes	5 minutes	5 minutes	5 minutes
Walk time weight in relation to IVTT	2.5	2	2.5	2	2.5	2
Drive time weight in relation to IVTT	2.5	2	2.5	2	2.5	2
Transfer time weight in relation to IVTT	2.5	2	2.5	2	2.5	2
Transfer penalty time weight in relation to IVTT	2.5	2	2.5	2	2.5	2

Several procedures were developed to determine accuracy and reasonableness of the transit path travel times that are used as input into the access and egress mode choice models. In the first check, total travel time was mapped from select airports and conventional rail stations to assess spatial reasonableness. Initial results from these maps showed missing transit path options from TAZs that should have transit availability. This finding led to increase the number of maximum transfers from three to four in conjunction with increasing the transfer penalty and factor, allow for greater number of paths to be enumerated through the spread function[15], and fix some errors in the access path generation.

The following maps show total transit travel time to select airports for the final air and CVR skims. Figure 4.7 shows transit total travel time to the San Francisco, Los Angeles, San Diego, Fresno, and Sacramento airports. Figure 4.8 shows transit total travel time San Francisco Transbay, Los Angeles Union Station, and Bakersfield conventional rail stations. The figures illustrate the much higher accessibility by transit to airports compared to conventional rail stations. This is because conventional rail also is an access mode to air. The skims allow for an individual to drive up to 200 miles to access a conventional rail station. In contrast, an individual only can drive up to 5 miles to access an urban rail or bus station. Hence, transit access to CVR stations is clustered around urban rail and major roadways.

For the second check, walk and drive access times were mapped from selected airports. This check was conducted to ensure that the skims developed reasonable walk and drive access times in relation to the location of transit lines and the airport. In addition, maps were created reflecting the drive access time as a percentage of total transit time to ensure that the skims did not reflect unusually high-drive access times. When these maps were created for early versions of our skims, many paths had high percentages of drive time in relation to total travel time. Therefore, the skim specifications were changed to increase the weight on drive access and egress time.

Figure 4.9 shows walk and drive access time to San Francisco, Sacramento, Los Angeles, and San Diego airports. Paths with walk access are concentrated in downtown areas and near stations. Drive access time increases as distance from transit lines and highways increases. Figure 4.10 plots drive access time as a percentage of total travel time to select airports. As distance increases from transit stations, the drive access time increases.

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[15] The spread function allows the modeler to adjust the number of routes enumerated by telling the transit pathbuilding algorithm when to stop looking for additional routes. Modelers can specify a "spread," an upper-cost limit for routes between an OD pair when using multirouting. The route-enumeration process uses the costs from the minimum cost routes and the spread to determine a maximum cost value for "reasonable" routes to that destination.

Figure 4.7 Total Transit Travel Time to Select Airports

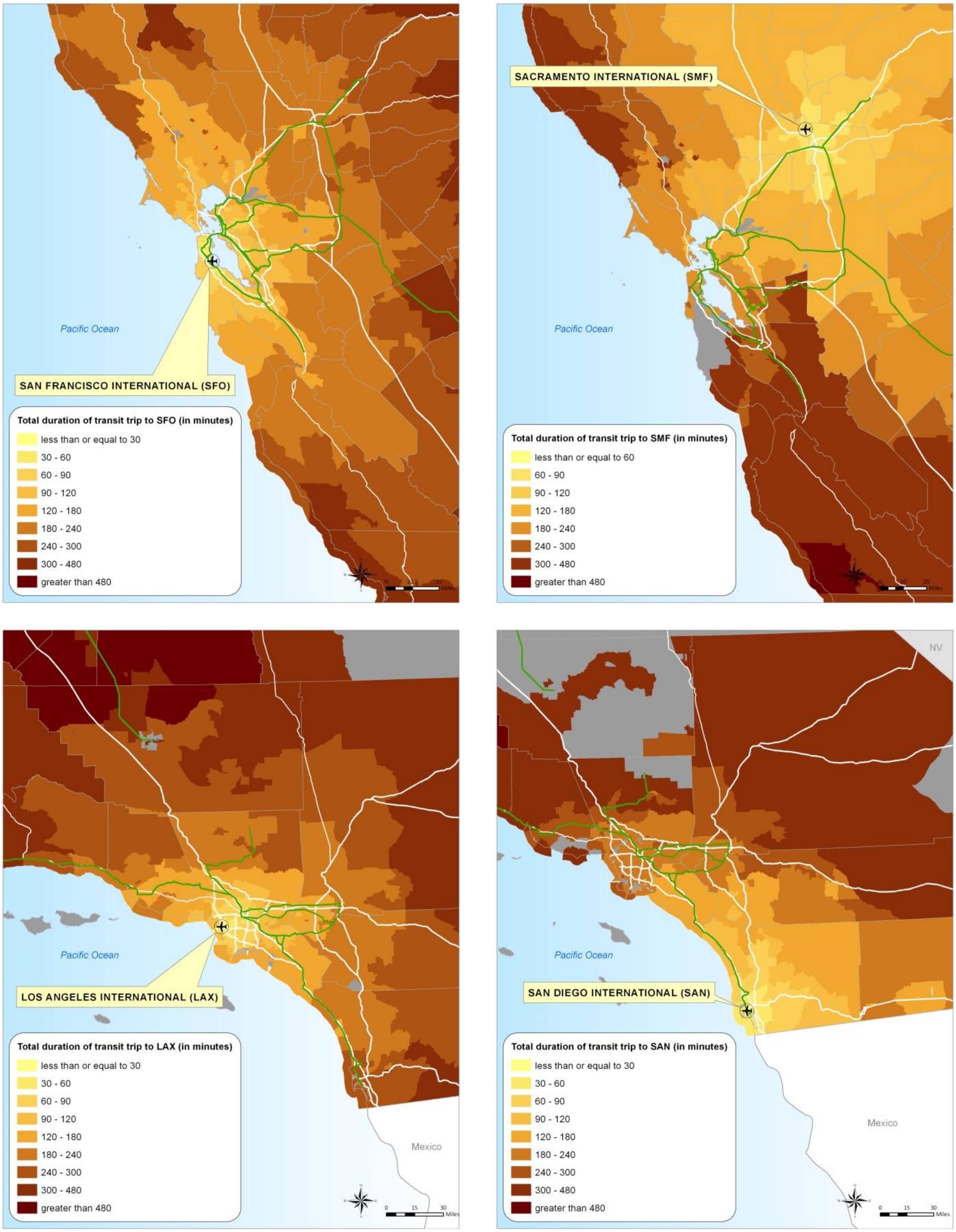


Figure 4.8 Total Transit Travel Time to Select Conventional Rail Stations

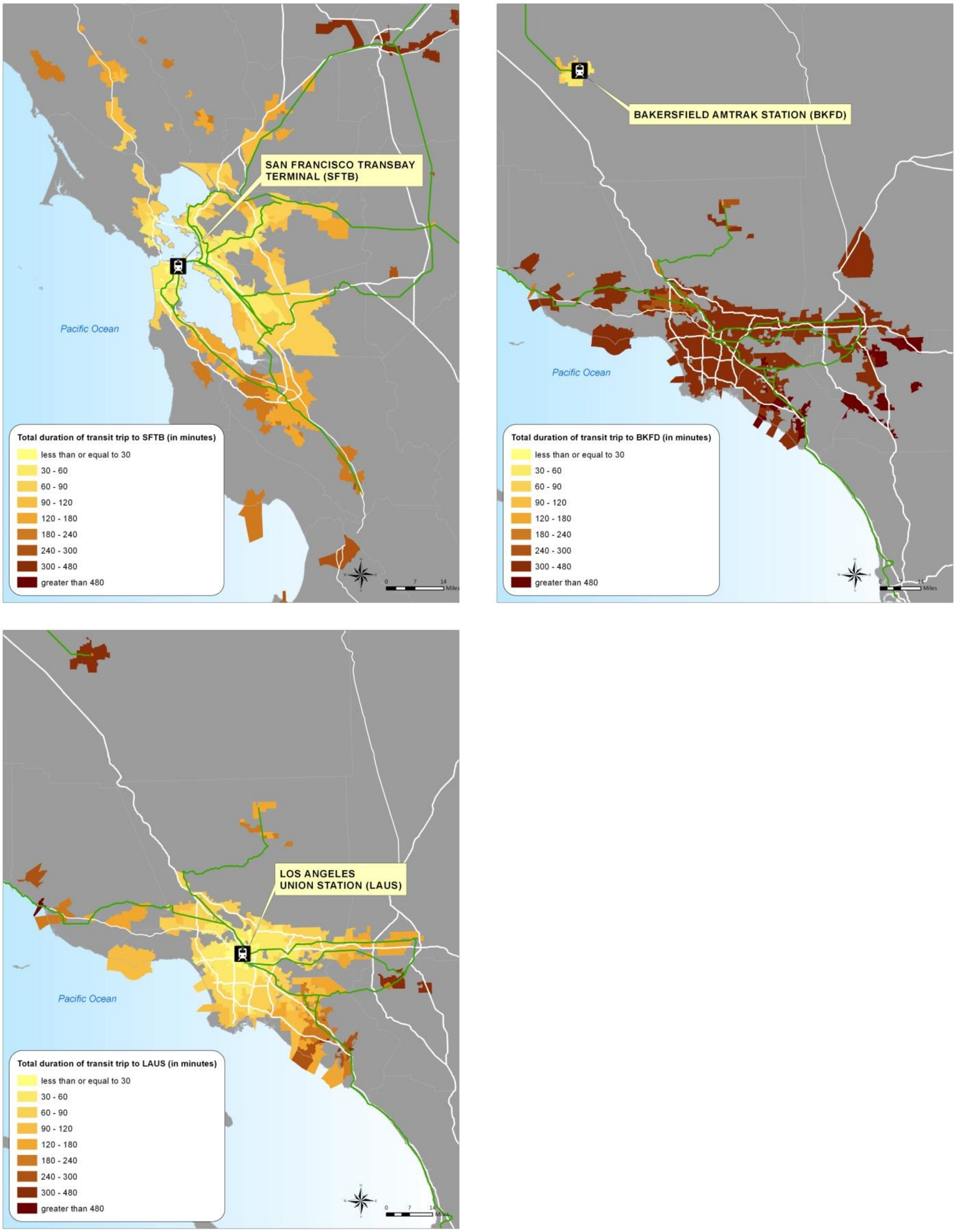


Figure 4.9 Drive Access Time to Select Airports

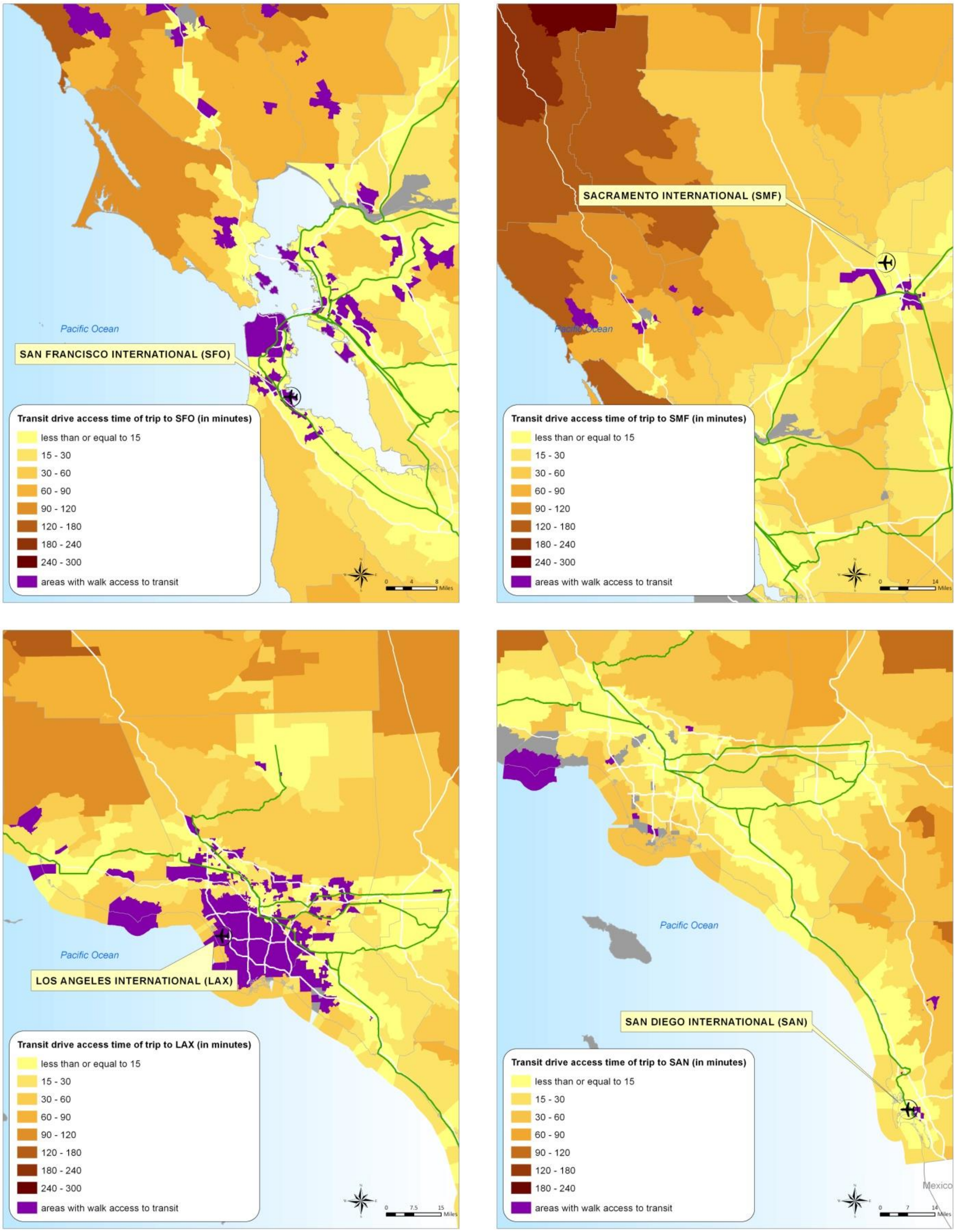
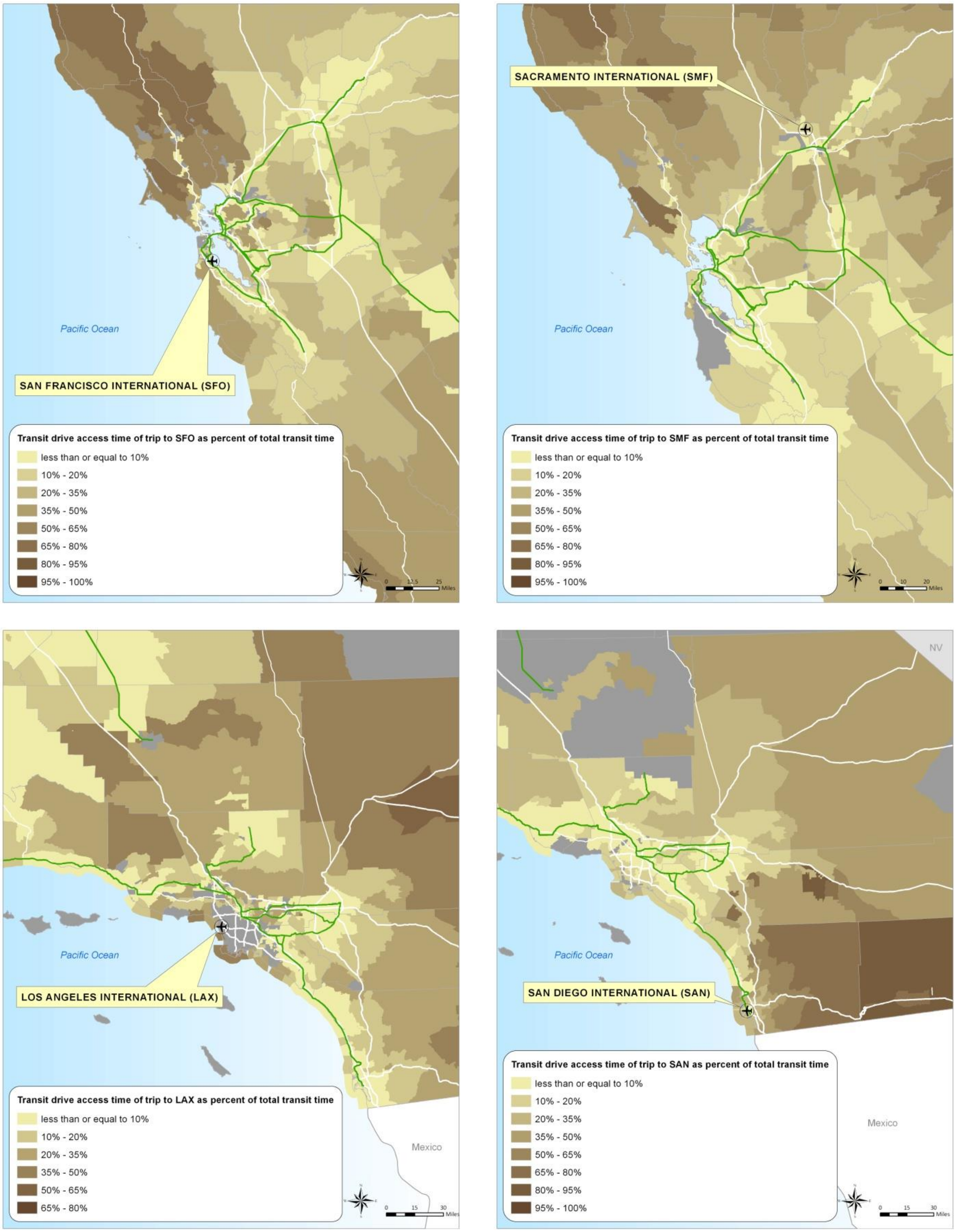


Figure 4.10 Drive Access Time as a Percentage of Total Travel Time to Select Airports



In the final check, the travel times were compared from the transit skims to the stated travel time of survey respondents who reported driving to and from an airport in the year 2005 RP survey data. For the intercept surveys that reported categorical travel times, the difference between the skimmed travel time and stated travel time was computed as the minimum difference within each travel time category. For the telephone surveys that reported actual stated travel time, the difference was computed directly by subtracting the stated travel time from the highway skimmed travel time. In initial comparisons, the skimmed travel time was, on average, much higher than stated travel times. Thus, the value of time was increased in the skims to ensure that cost was not the driving factor in choosing best paths. In addition, the initial wait time was capped at 15 minutes.

Table 4.10 shows the comparison of the transit skim travel time to the stated travel time from the surveys. The final transit skims match very well to the stated travel times. Close to 79 percent of the surveys have skimmed and stated travel times within 10 minutes of each other. Almost 88 percent of the surveys have skimmed and stated travel times within 30 minutes of each other. Select TAZ pairs from the surveys with stated and skimmed travel times more than 45 minutes apart were spot checked to ensure that the highway skims were accurate. In all of these cases, the stated travel times were erroneously reported as too high or too low. The surveys that differ substantially in travel time compared to the skimmed travel time either have erroneous stated travel times or have high transfer times. It was decided not to cap transfer wait time to reflect the low service frequency of these routes, and to further penalize routes that require transfers.

Table 4.10 Transit Skim Travel Time in Comparison to Revealed-Preference Air Survey Stated Transit Travel Time

Transit Skim in Relation to Stated Travel Time	Percentage
More than 45 minutes lower	8.2%
30 to 45 minutes lower	1.6%
10 to 30 minutes lower	8.9%
Less than 10 minutes lower	66.5%
Less than 10 minutes higher	12.4%
10 to 30 minutes higher	0.0%
30 to 45 minutes higher	0.0%
More than 45 minutes higher	2.3%

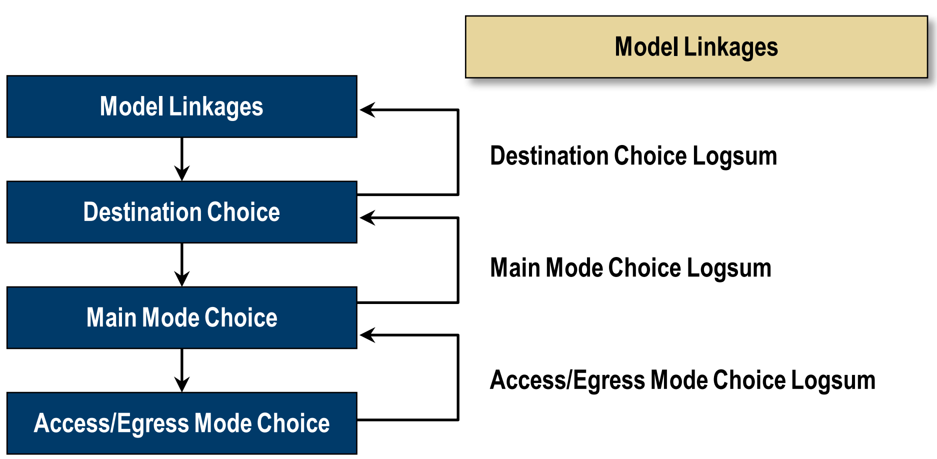
5.0 Long-Distance Model Estimation

The long-distance model estimates the number of business, commute, recreation, and other trips per average day that are made between TAZ pairs (more than 50 miles) within California and the mode of travel used to make these trips. Long-distance trips are defined as any trip made to a TAZ 50 miles or more from the respondent's home TAZ with one end of the trip at the respondent's home. The model components are:

- Trip frequency model, which estimates whether a household undertook no long-distance trips, one long-distance trip alone, or one long-distance trip in a group on an average day;
- Destination choice model, which estimates the destinations of home-based trips; and
- Mode choice model, which estimates the choice of main mode (e.g., auto, air, conventional rail, or high-speed rail), as well as access/egress mode.

These models interact with each other through logsums, which are fed up through the models, as shown in Figure 5.1. The next sections discuss the development of these models in the order they were estimated.

Figure 5.1 Long-Distance Model Structure



5.1 ACCESS/EGRESS AND MAIN MODE CHOICE MODEL ESTIMATION

This section details the joint main mode choice and access/egress model estimation process and results.

Estimation Datasets

The estimation dataset includes data from two different datasets: 1) 2012/2013 long-distance component of the CHTS, and 2) 2005 RP/SP Survey.

2012/2013 Long-Distance Component of the CHTS

The Version 2.0 main mode choice model estimation dataset used responses from the entire long-distance survey results (about 42,000 households).

Access/egress choice information from the CHTS was not used for model estimation. The access/egress mode options coded in the survey did not record the difference between drive-park and drop-off.

2005 RP/SP Survey

The model uses both RP and SP choice information for main mode choice model estimation (supplementing the data from the CHTS). RP access/egress choice information was used for access/egress mode choice model estimation supplementing the data from the CHTS. SP access/egress choice information was not used. Attributes for the access/egress options (and station/airport options) were not shown to respondents in the SP survey.

Each SP response was given a weight of 0.25 to account for the fact that four SP exercises were presented to each respondent. The final weights used in the model were rescaled so that the sum of model weights equaled the number of observations. Note that all observational weights were rescaled, including the CHTS RP responses.

Table 5.1 shows the unweighted distribution of main mode choices by purpose for the RP and SP survey datasets.

Table 5.1 RP/SP and Main Mode Choice Distribution in Dataset

Survey	Mode	Business/Commute Frequency	Business/Commute Percent within Mode Group	Business/Commute Percent of All Observations	Recreation/Other Frequency	Recreation/Other Percent within Mode Group	Recreation/Other Percent of All Observations
RP	Car	3,376	74.8%	41.8%	13,933	94.6%	68.0%
	Air	890	19.7%	11.0%	610	4.1%	3.0%
	HSR	–	–	–	–	–	–
	CVR	247	5.5%	3.1%	181	1.2%	0.9%
	Total	4,513	100.0%	55.9%	14,724	100.0%	71.8%
SP	Car	389	10.9%	4.8%	2,122	36.7%	10.4%
	Air	581	16.3%	7.2%	305	5.3%	1.5%
	HSR	2,330	65.3%	28.8%	3,085	53.4%	15.0%
	CVR	266	7.5%	3.3%	263	4.6%	1.3%
	Total	3,566	100.0%	44.1%	5,775	100.0%	28.2%
Total		**8,079**		**100.0%**	20,499		**100.0%**

Estimation Procedures

Full information maximum likelihood (FIML) techniques were used to simultaneously estimate the joint main mode and access/egress models. This approach was in contrast to the estimation of the Version 1 models, where access/egress mode choice was estimated separately from the main mode choice, and logsum information from the access/egress mode choice model was used in the main mode choice model estimation. This approach allowed relationships between access/egress utility coefficients and main mode utility coefficients to be consistently estimated and, if necessary, constrained in ways that would otherwise not have been possible. In addition, normalized utility coefficients were estimated directly using R programming language.

Mode Availability

Mode availability criteria were based on modeling long-distance travel in production-attraction format. Under this approach, the home zone was always the production zone, and the nonhome zone was always the attraction zone. This approach allowed for reasonable assumptions regarding mode availability for access to and egress from the main mode. Availability criteria included the following:

- Main modes were marked as unavailable if the total access plus egress car time exceeded the direct origin to destination time by auto.
- For access mode choice, rental car was considered an invalid mode option.

- For access mode choice, drive-park was considered an invalid mode option if parking was not available at the access station.
- For egress mode choice, drive-park was considered an invalid mode option.
- For both access and egress mode choice to air (main mode), walk was considered an invalid mode option.
- For egress mode choice, rental car was considered an invalid mode option if no rental car facilities existed at the egress station.
- For access/egress mode choices, taxi was considered an invalid option if access/egress travel distance exceeded 75 miles. The outlier analysis in the previous round of estimation helped to identify very high taxi distances as an issue in two cases.

Cost and Time Relationships between Access/Egress and Main Mode Choices

The model is estimated with the assumption that a unit of cost should be perceived the same whether it occurs during the access/egress portion of the journey or the main mode portion of the journey. This constraint was used in each model specification tested. The perception of cost was not the same for all travelers, since separate cost coefficients were estimated for different travel purposes and income groups.

For travel time, a unit of travel time is treated differently depending on the leg of the trip. To ensure that ridership would not increase when a station was moved farther away from a zone, our model estimation approach was based on the assumption that the disutility associated with access/egress time should be <u>at least</u> as onerous as the disutility associated with main mode time.

We included a variable, "AE time to MM time Ratio," in the model estimation. This variable ($\beta_{ae,tt,ratio}$) was a factor on the access/egress time applied to the total access/egress time in addition to the relevant in-vehicle time coefficient (β_{ivt}). The (dis)utility associated with travel time at the access/egress level is given by the following equation:

$$U_{ae,tt} = \beta_{ivt}(\beta_{ae,tt,ratio}[IVT_{ae} + \beta_{ovt,ratio} * OVT_{ae}])$$

$\beta_{ovt,ratio}$ is the out-of-vehicle time to in-vehicle time ratio, which was ultimately constrained in the business/commute and recreation/other models to 2.5 and 2.0, respectively. The constraints were comparable to values used in many urban mode choice models.

The $\beta_{ae,tt,ratio}$ coefficient was consistently estimated to be well over 1.50 for the various business/commute models investigated and, therefore, was constrained to be 1.50 in the final model estimation. For the recreation/other models tested, the ratio was typically in the range of 0.8 to 0.9. For increased consistency with the business/commute model and to prevent travelers from traveling for more time on access/egress modes to "avoid" travel on main modes, the final ratio was constrained to 1.2 for the recreation/other model. The coefficients suggest that the disutility associated with access/egress travel time is 50 percent or 20 percent greater than the disutility associated with main mode travel time, depending on the purpose of the trip.

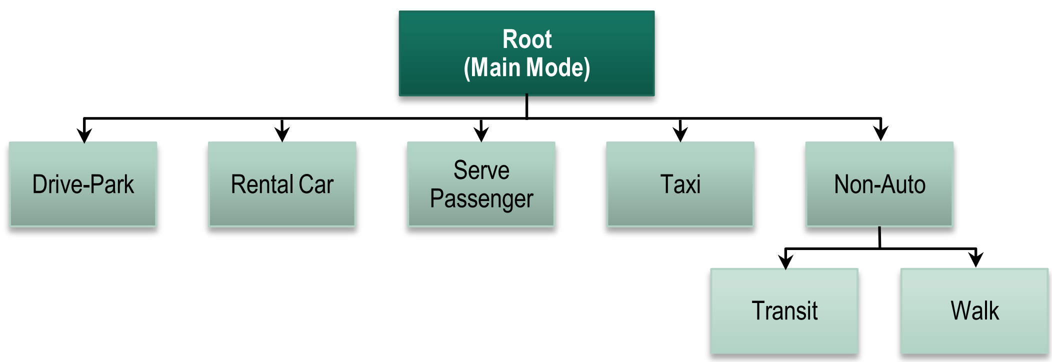
In summary, the estimated cost and in-vehicle time coefficients are generic. They apply to both access/egress mode choices, as well as main mode choices. For travel time, differences in traveler perceptions across access/egress and main modes are modeled via the $\beta_{ae,tt,ratio}$, coefficient, while traveler perceptions of cost are constrained to be equal across access/egress and main modes.

Nesting Structures

Access/Egress Nesting Structure

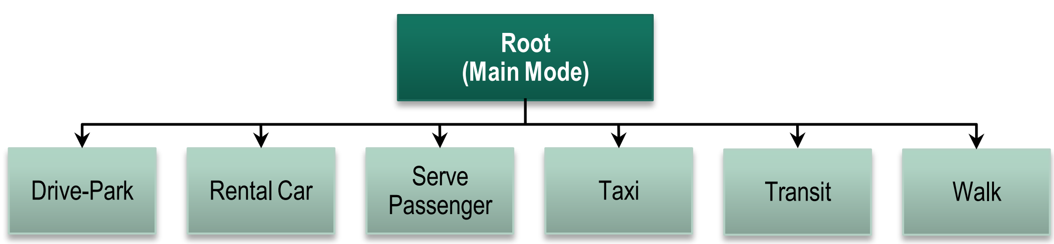
In the initial model estimation effort, we tested several potential nesting structures for access/egress mode choice relative to the main mode. The only structure that consistently yielded reasonable results is shown in Figure 5.2.

Figure 5.2 Initial Model Estimation Access/Egress Mode Nesting Structure



The nesting coefficients estimated using the nesting structure, shown in Figure 5.2, were not very strong, suggesting a simpler structure for the access and egress mode choices. The final model structure for access and egress mode choices used a multinomial logit structure, as shown in Figure 5.3.

Figure 5.3 Final Model Estimation Access/Egress Mode Choice Structure



Main Mode Nesting Structure

In the initial model estimation effort, the main mode choice used the nesting structure shown in Figure 5.4. Access/egress mode choices nested below air, HSR, and CVR. We obtained suboptimal nesting coefficients using the Figure 5.4 nesting structure and, for the business/commute purpose, the nesting coefficient was estimated to be greater than 1, which is unreasonable. For the final models, the nesting structure was replaced with the structure shown in Figure 5.5. Better estimation results were obtained with the Figure 5.5 structure.

Figure 5.4 Initial Main Mode Choice Model Nesting Structure

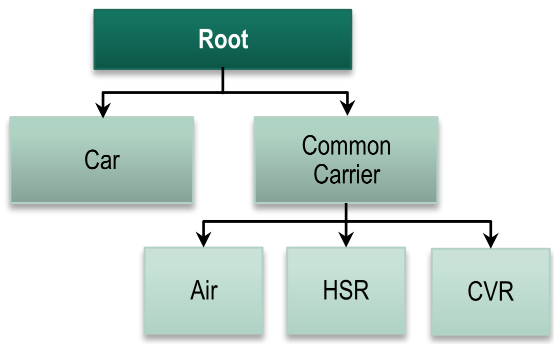
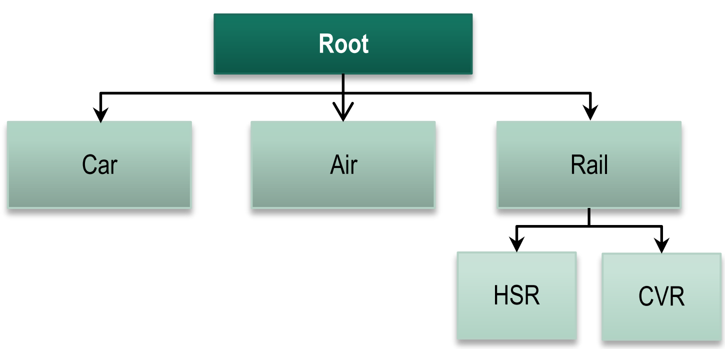


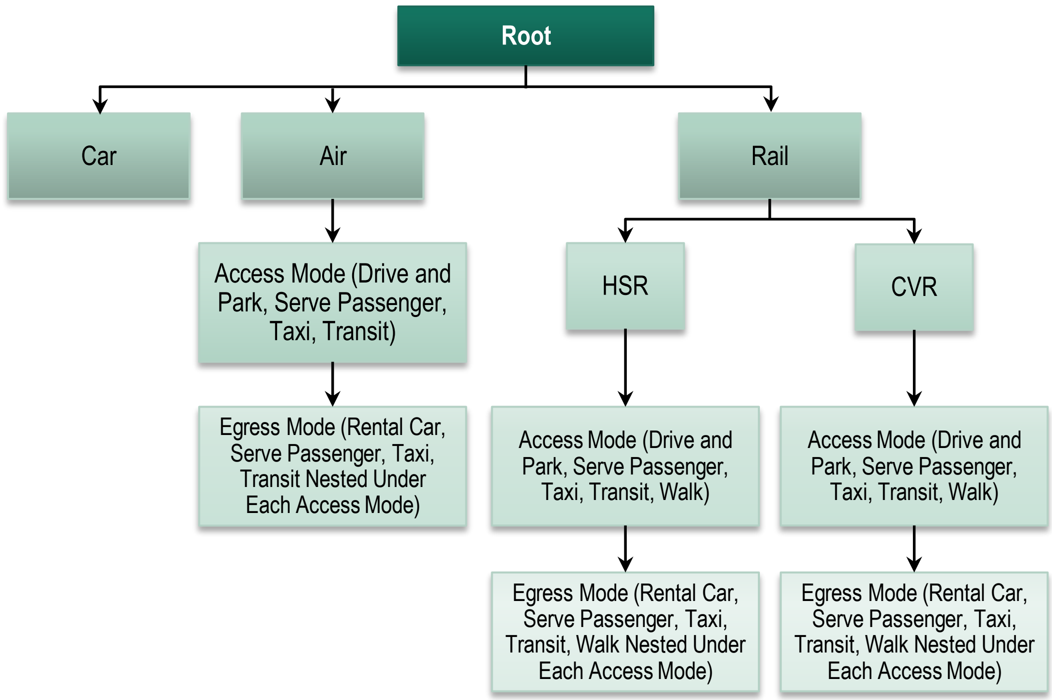
Figure 5.5 Final Main Mode Choice Model Nesting Structure



Overall Nesting Structure

In the FIML estimation procedure, access and egress choices appeared as nested alternatives under air, HSR, and CVR main mode choice alternatives. This overall nesting structure of the models is shown in Figure 5.6.

Figure 5.6 Nesting Structure for Joint Estimation of Main Mode – Access/ Egress Model



The nesting of egress mode choice under access mode choice may be deceiving. Since egress mode alternatives and utilities are identical for each access mode, the egress mode logsums have no impact on access mode choice. In effect, they are comparable to adding a constant to each of the access modes.

The resulting model is equivalent to having access and egress mode alternatives both nested directly (but independently) below the air or rail main modes.

Estimation Results

The estimated models for the business/commute trip purposes are shown in Tables 5.2 and 5.3 and for recreation/other purposes in Tables 5.4 and 5.5.

Tables 5.2 and 5.4 show the coefficients for the LOS variables, model fit statistics, and important relationships. Tables 5.3 and 5.5 show the alternative-specific coefficients and constants as estimated using the FIML techniques.

The coefficients and constants shown in Tables 5.3 and 5.5 were adjusted during model calibration to better reproduce observed travel choices from the expanded 2012/2013 CHTS, CVR boardings obtained from various operators, and airport-to-airport trips summarized from the BTS 10 percent ticket sample data, as described in Section 7.0.

Table 5.2 LOS Variables and Model Fit – Business/Commute Mode Choice Models

Modes	Variable	Units for Variable	Coefficient	t-stat
LOS Variables				
MM and AE	IVT – All	Minutes	-0.0101	-18.7
	Cost – All	2005 Dollars	-0.0152	-8.3
	Cost – Low-Income (Additive to Cost-All)	2005 Dollars	-0.0050	-0.7
	Cost – High-Income (Additive to Cost-All)	2005 Dollars	0.00014	0.1
	Cost – Missing Income (Additive to Cost-All)	2005 Dollars	0.00015	0.1
	Cost – Commute (Additive to Cost-All)	Dollars (in 2005$)	-0.0067	-1.9
MM	Log (1+Headway/60)	(Headway in Minutes)	-0.3150	-3.1
	Reliability (excluding RP response for car)	Percent (0-100)	0.0125	2.5
AE	Taxi Cost per Mile	Miles	1.665	6.4
	OVT to IVT Ratio	–	2.50	Constrained
	AE Time to MM Time Ratio	–	1.50	Constrained
Structural Parameters				
N/A	Scale – SP		0.478	-11.3[a]
	Access Logsum		0.643	-4.8[a]
	Egress Logsum		0.592	-8.2[a]
	Rail Nesting Coefficient		0.799	-1.2[a]
Observations			**8,079**	
Log Likelihood – Constants Only			-7041.9	
Log Likelihood at Convergence			-4815.9	
Rho Squared			0.316	
Values of Time			**2005$/Hour**	**2012$/Hour**
Low-income, business			$30.11	$35.39
Medium-income, business			$40.05	$47.07
High-income, business			$40.43	$47.52
Missing income, business			$40.46	$47.56
Low-income, commute			$22.60	$26.57
Medium-income, commute			$27.78	$32.66
High-income, commute			$27.96	$32.87
Missing income, commute			$27.98	$32.89

[a] t-stat measured in relation to 1.0, not 0.0.

Table 5.3 Alternative-Specific Variables – Business/Commute Mode Choice Models

Modes	Variable	Coefficient	t-stat
Main Mode Alternative-Specific Variables			
Car	Traveling in Group	1.109	10.5
	No Cars in Household	-1.074	-3.1
	Cars Less Than Workers	-0.349	-1.5
	Missing Income	-0.798	-4.9
	SP Car Inertia	3.677	6.3
Air	ASC – RP	-3.504	-9.1
	ASC – SP	-4.396	-3.3
	High-Income	0.506	2.9
	Commute	-1.667	-4.9
	SP Air Inertia	5.422	4.3
HSR	ASC – SP	1.993	5.2
	High-Income	0.332	1.2
	Commute	-0.830	-1.7
CVR	ASC – RP	-4.902	-11.2
	ASC – SP	-0.842	-0.9
	Commute	-0.505	-2.0
	SP CVR Inertia	1.886	2.5
Access/Egress Mode Alternative-Specific Variables			
Drive-Park	ASC – Access	1.047	8.1
	Commute	0.832	4.9
	Cars Less Than Workers (Access Mode Choice Only)	-0.476	-2.8
	Low-Income	-1.463	-2.3
	Log (1 + Employment Density at Airport or Station – 2 mi buffer)[b]	-0.020	-2.0
Rental Car	ASC – Egress	0.547	7.0
	Commute	-0.714	-1.9
Serve Passenger	One person Household (Access Mode Choice Only)	-0.417	-2.8
Taxi	ASC – Access	-0.466	-3.2
Transit	ASC – Egress	0.312	2.3
	Commute	0.312	1.8
	Log (1 + Employment Density at Airport or Station – 2 mi buffer)[b]	0.055	4.1
	ASC – Access	0.338	1.3
	ASC – Egress	1.326	7.4
	Commute	1.016	5.3

Modes	Variable	Coefficient	t-stat
	Cars Less Than Workers (Access Mode Choice Only)	0.872	2.7
	Log (1 + Employment Density at Airport or Station – 2 mi buffer)[b]	0.068	4.2
	Car Used in Transit Path	-0.512	-4.0
	Bus Used in Transit Path	-0.482	-3.1
Walk	ASC – Access and Egress	1.065	1.4

[a] Estimated coefficients in this table were subject to modification in the model calibration process.

[b] Total employees per square mile within 2 miles of the main mode airport or station.

Table 5.4 LOS Variables and Model Fit – Recreation/Other Mode Choice Models

Modes	Variable	Units for Variable	Coefficient	t-stat
LOS Variables				
MM and AE	IVT	Minutes	-0.0068	-15.6
	Cost	Dollars (in 2005$)	-0.0188	-14.8
	Cost – High-Income	Dollars (in 2005$)	0.0022	1.8
	Cost – Missing Income	Dollars (in 2005$)	0.0002	0.1
MM	Log (1+Headway/60)	(Headway in Minutes)	-0.4126	-4.9
	Reliability (excluding RP response for car)	Percent (0-100)	0.0031	0.9
AE	Taxi Cost per Mile	Miles	1.83	5.3
	OVT to IVT Ratio	–	2.00	Constrained
	AE Time to MM Time Ratio	–	1.20	Constrained
Structural Parameters				
N/A	Scale – SP		0.642	-7.1[a]
	Access Logsum		0.442	-8.6[a]
	Rail Nesting Coefficient and Egress Logsum		0.519	-8.0[a]
Observations			**20,499**	
Log Likelihood – Constants Only			-6664.0	
Log Likelihood at Convergence			-4888.5	
Rho Squared			0.266	
Values of Time			**2005$/Hour**	**2012$/Hour**
Low-income			$21.64	$25.44
Medium-income			$21.64	$25.44
High-income			$24.55	$28.86
Missing income			$21.89	$25.73

[a] t-stat measured in relation to 1.0, not 0.0.

Table 5.5 Alternative-Specific Variables – Recreation/Other Mode Choice Models

Modes	Variable	Coefficient	t-stat
Main Mode Alternative-Specific Variables			
Car	Traveling in Group	1.982	12.6
	Household Size	0.0519	1.4
	No Cars in Household	-0.984	-3.8
	Cars Less Than Workers	-0.357	-2.0
	SP Car Inertia	2.466	6.8
Air	ASC – RP	-1.734	-5.2
	ASC – SP	0.581	1.1
	Traveling in Group	-0.270	-1.8
	SP Air Inertia	2.220	4.9
HSR	ASC – SP	3.275	9.2
CVR	ASC – RP	-2.972	-8.6
	ASC – SP	2.241	5.4
	Low-Income	0.353	1.8
	High-Income	-0.272	-2.1
	Missing Income	-0.520	-1.9
	SP CVR Inertia	1.158	4.3
Access/Egress Mode Alternative-Specific Variables			
Drive-Park	ASC – Access	-0.0889	-1.0
	Cars Less Than Workers (Access only)	-0.905	-2.8
	Traveling in Group	0.768	5.5
Rental Car	ASC – Egress	-0.610	-5.1
	Low-Income	-0.443	-1.5
	Traveling in Group	0.539	3.5
Serve Passenger	One Person Household (Access only)	-0.211	-2.0
	Low-Income	0.154	1.8
Taxi	ASC – Access	-0.478	-2.6
	ASC – Egress	-0.527	-2.8
	Traveling in Group	0.771	6.0
	Log (1 + Employment Density at Airport or Station – 2 mi buffer)[b]	0.025	1.6
Transit	ASC – Access	0.316	1.3
	ASC – Egress	0.500	2.5
	Cars Less Than Workers (Access only)	0.413	2.0
	Log (1 + Employment Density at Airport or Station – 2 mi buffer)	0.0381	2.4

Modes	Variable	Coefficient	t-stat
	Car Used in Transit Path	-0.528	-3.6
	Bus Used in Transit Path	-0.343	-1.9
Walk	ASC – Access	0.501	1.8
	ASC – Egress	0.733	4.0

[a] Estimated coefficients in this table were subject to modification in the model calibration process.

[b] Total employees per square mile within 2 miles of the main mode airport or station.

The business/commute model estimation results have the following characteristics:

- All travel time and cost coefficients have correct signs and reasonable relative relationships.
- Values of travel time (in 2005 dollars) for the business purpose ranged from $30 per hour for low income to $40 per hour for high income. For the commute purpose, the values of time ranged from $23 per hour for low income to $28 per hour for high income. In 2012 dollars, the ranges were $35 per hour to $48 per hour for business and $27 per hour to $33 per hour for commute.
- Cost coefficients are additive. For example, cost coefficient for low-income business travelers is made up of the base cost coefficient, -0.0152, plus the cost coefficient for low-income travelers, -0.0050, which yields a net cost coefficient of -0.0202.
- We attempted to estimate a commute-specific IVT coefficient. However, it produced larger values of time for the commute purpose than for the business purpose. We considered this to be unreasonable and, therefore, dropped the variable in the estimation of the final model.
- We have adopted nonlinear representations of main mode headways for the final models. We tested both log transformations of frequencies of service (the inverse of service headways) and headways. Unreasonable coefficient estimates emerged in the business/commute model when frequencies were used in place of headways. Therefore, the final model specifications used a logarithmic transformation of headway.
- The access/egress time to main mode time ratio was initially estimated to be greater than 2.0 and was constrained to a value of 1.5 in the final estimation. The implication was that the disutility of access/egress travel time was 50 percent higher than the disutility of main mode travel time.
- Nesting coefficient estimates for access and egress mode choices are both approximately 0.6, while the main mode rail nest coefficient estimate is about 0.8.
- Main mode and access/egress alternative-specific coefficients had reasonable signs and relative magnitudes.

- The "traveling in group" coefficient specific to car main mode was estimated to be 1.11, which is equivalent to reducing the cost of travel by car by $73 for medium-income business travelers and $51 for medium-income commute travelers. This makes sense because costs associated with car travel are not adjusted for party size.
- The positive coefficients for high-income travelers for (air and HSR) suggest that high-income travelers are more likely to use those "premium modes."
- SP inertia variables for each existing main mode were positive and highly significant, suggesting that RP choices were very likely to be repeated in the SP experiments.

The recreation/other model estimation results have the following characteristics:

- All LOS and cost coefficients had correct signs and reasonable relationships. An exception was the low-income cost coefficient, which was removed from the final model.
- Values of travel time in 2005 dollars ranged from $22 per hour to $25 per hour. In 2012 dollars, the ranges were $25 per hour to $29 per hour.
- The access/egress time to main mode time ratio was initially estimated to be less than 1.0 (about 0.93) and was constrained to 1.20 in the final specification. This implies that the disutility of access/egress travel time was 20 percent higher than the disutility of main mode travel time.
- The nesting coefficient estimates for access and egress mode choices were 0.44 and 0.52, respectively, which were reasonable and generally consistent with the business/commute model. When left unconstrained, the estimate of the rail nesting coefficient was less than the egress logsum coefficient. Therefore, in the final specification, the values for those two coefficients were constrained to be the same value, 0.52.
- Main mode and access/egress alternative-specific variables had reasonable signs and magnitudes.
- The "traveling in group" variable specific to car main mode was estimated to be 1.98, which was equivalent to a reduction in cost for car travel of $105 for medium-income travelers. That value was generally consistent with the value found for the business/commute purpose.
- The "traveling in group" variable specific to air main mode was negative and estimated to be -0.270. This is equivalent to an increase in cost for air travel of $14 for medium-income travelers.
- The SP inertia variables for each existing main mode were positive and highly significant, suggesting that RP choices were very likely to be repeated in the SP experiments.

5.2 DESTINATION CHOICE MODEL ESTIMATION

This section details the destination choice model estimation process and results.

Estimation Datasets

Like the main mode and access/egress choice models, the destination choice models were estimated using data from two datasets:

1. The 2012 Long-distance portion of the CHTS.
2. The 2005 RP/SP Survey. Only the RP portion of the survey was used for destination choice model estimation.

One important variable considered in the destination choice models is the mode choice logsum. This variable relies on specific estimated mode choice model parameters and structure, as documented in Section 5.1. Note that the logsum calculations used in destination choice model estimation come from the estimated access/egress and main mode choice models, not the calibrated ones.

For purposes of the long-distance model, it was decided that the best measure of distance would be the straight-line distance from TAZ centroid to TAZ centroid, since the long-distance trip definition will not change if network conditions and highway skims change for forecast years.

Destination Choice Model Design

Compared to the Version 1.0 destination choice models, the general specifications were altered in several ways, and a number of variables was tested as follows:

- Version 1.0 models included three distance variables (distance, distance squared, and distance cubed). In Version 2.0, a piecewise linear distance specifications were tested with breakpoints every 50 miles.
- Land-use (area type) variables were revised. A revised intensity variable was generated using a two-mile buffer around each zone. Buffer distances were based on centroid-to-centroid distances, which results in a relatively straightforward calculation that can be easily coded for model application. The revised intensity variable is formulated as follows:

$$[Intensity]_{2i} = \frac{\sum_{j \in C_i}\left([HH]_j + [EMP]_j\right)}{\sum_{j \in C_i}[AREA]_j}$$

  Here, C_i is the set of all zones with centroid-to-centroid distance of less than two miles. For completeness, intrazonal centroid-to-centroid distance is taken to be zero miles for all zones, thus, ensuring zone i is always a member of C_i.

Using this intensity measure, thresholds were devised to categorize each zone into one of five area type definitions. Area types were defined as follows and units were expressed as households and workers per square mile:

- Rural: $[Intensity]_{2i} \leq 1{,}000$;
- Suburban: $1{,}000 < [Intensity]_{2i} \leq 4{,}000$;
- Urban: $4{,}000 < [Intensity]_{2i} \leq 7{,}000$;
- CBD Fringe: $7{,}000 < [Intensity]_{2i} \leq 15{,}000$; and
- CBD: $[Intensity]_{2i} > 15{,}000$.

The new area type definitions result in much more contiguous area types, particularly for the densest area types. Area types remain largely the same for large zones, since large zones typically do not have neighboring zones with centroid-to-centroid distances less than two miles.

- County/regional indicator variables were not used, though regional-specific indicator variables were interacted with area type variables (e.g., we did not use a SCAG indicator, but did consider a SCAG CBD indicator).
- The value of segmenting size variables by income was explored.
- A more disaggregate set of employment variables in the size function was explored. The size function was defined as follows:

$$[Size]_i = ln\left(\sum_k \exp(\beta_k) \times Z_{ik}\right)$$

Here, β_k is a size parameter to be estimated, and Z_{ik} is the k^{th} size variable for zone i. One size parameter must be constrained to zero for the model to be statistically identified. The exponent in the expression above ensures that each size variable has a nonnegative effect on the size function.

- Accessibility variables related to specific large attractors (e.g., Disneyland) were explored, especially for the recreation trip purpose.
  - Accessibility measures were generated using the following formula:

$$Acc_{ij} = \frac{2}{\max\left(2, Distance_{ij}^2\right)}$$

Here, accessibility is measured for zone i to large attractor j (where j is simply the zone corresponding to the large attractor), and the distance is the straight-line distance. The accessibility value takes values between 0 and 1, with locations close to the large attractor taking larger values.

Estimation Results

The estimated models for the business, commute, recreation, and other trip purposes are shown in Tables 5.6, 5.7, 5.8, and 5.9. Some general findings and notes made during model estimation include the following:

- **Travel Distance Variable**. For each of the four trip purposes, distance variables were tested. In each case, the distance measures were found to have a great deal more explanatory power than the mode choice logsum, resulting in very low (and sometimes negative) coefficient estimates on the logsum variable. Nonetheless, the panel made a strong argument that distance variables were needed. Thus, in each of the specifications presented below, the coefficient on mode choice logsum was constrained to be 0.05, a larger value than the values that were estimated.
- **Piecewise Linear Distance Variables**. For each of the four trip purposes, piecewise linear distance variables were tested with breakpoints every 50 miles, starting with the 100-mile breakpoint and ending with the 550-mile breakpoint. A base distance variable also was included. The following is a general trend in each of the models:
  - A substantial impact of distance on the utility of travel in the 50- to 200-mile range;
  - A subdued impact of distance on utility in the 300- to 450-mile range; and
  - Again, a substantial impact on utility for distances more than 450 miles.

  The minimal impact of distance on disutility is a result of the MTC-SCAG and SACOG-SCAG markets falling in this range. To ensure monotonic distance effects across the relevant distance range, all but two piecewise linear distance variables were dropped in the model for each trip purpose. The first breakpoint varied by trip purpose for the distance range from 100 to 200 miles, while the second breakpoint at 450 miles was found to work well for each purpose.

  Figure 5.7 shows the impacts of distance on utilities for the four models using an observation that belongs to the high-income market segment.
- **Size Variable Segmentation by Income**. While a number of models that includes segmentation of size variables by income was tested, there were mixed results in terms of the implied travel behavior. Therefore, the income segmentation of size variables was removed.
- **Size Variable Statistics**. The tables with estimation results do not show t-statistics related to the size variables. The models are applied, such that the exponent of the reported coefficient is multiplied by the size variable. Therefore, a coefficient of zero in the tables means that the actual coefficient is one. However, the t-statistic for a coefficient of zero would be zero, suggesting the coefficient is not significant, when, in fact, it may be highly significant. Therefore, in lieu of t-statistics, standard errors of the size coefficient estimates were reported.

Table 5.6 Destination Choice Coefficient Estimates – Business Purpose

Variables	Model B3	
Utility Variables	**Coefficient**	**t-stat**
Mode Choice Logsum	0.0500	a
Distance – All (per mile of straight line distances between TAZ centroids)	-0.0319	-22.8
Distance – Low-Income (additive to Distance – All)	-0.0052	-3.7
Distance – High-Income (additive to Distance – All)	0.0021	5.9
Distance – Missing Income (additive to Distance – All)	0.0032	6.0
Max (0, Distance-100 miles) (additive to Distance – All)	0.0285	18.8
Max (0, Distance-450 miles) (additive to Distance – All)	-0.0097	-4.7
CBD	0.156	1.9
CBD Fringe	-0.254	-4.2
Urban	-0.277	-5.1
Suburban	-0.259	-5.3
CBD or CBD Fringe – SACOG	1.71	18.8
CBD – MTC	0.813	8.4
CBD – SANDAG	1.13	9.5
Size Variables	**Coefficient**	**St. Err.**
Log Size Multiplier	1.00	a
Office Employment[a]	0.00	a
Primary Sector Employment[a]	-2.33	0.476
Education/Medical Employment[a]	-1.88	0.280
Leisure/Hospitality Employment[a]	1.54	0.098
Other Service Employment[a]	-0.483	0.513
Wholesale Trade + Transportation + Retail Trade Employment[a]	-0.750	0.205
Observations	3,633.000	
Log Likelihood at Zero	-30,057.500	
Log Likelihood at Convergence	-26,014.700	
Rho Squared	0.135	

[a] Size coefficients are exponentiated in the utility calculations. For example, the base office employment size coefficient of 0.0 is applied as exp(0.0) x office employment, or 1.0 x office employment.

Table 5.7 Destination Choice Coefficient Estimates – Commute Purpose

Variables	Model C3	
Utility Variables	**Coefficient**	**t-stat**
Mode Choice Logsum	.0500	a
Distance – All (per mile of straight line distances between TAZ centroids)	-0.0403	-23.0
Distance – Low-Income (additive to Distance – All)	-0.0026	-0.6
Distance – High-Income (additive to Distance – All)	0.0027	2.2
Distance – Missing Income (additive to Distance – All)	0.0031	1.8
Max (0, Distance-150 miles) (additive to Distance – All)	0.0367	17.8
Max (0, Distance-450 miles) (additive to Distance – All)	-0.0143	-1.7
CBD	-0.70	-5.4
CBD Fringe	-0.535	-6.0
Urban	-1.12	-12.7
Suburban	-1.18	-14.2
Size Variables	**Coefficient**	**St. Err.**
Log Size Multiplier	1.000	a
Office Employment[a]	0.000	a
Transportation Employment[a]	0.489	0.209
Education/Medical Employment[a]	-1.02	0.233
Leisure/Hospitality Employment[a]	0.103	0.225
Primary Sector + Wholesale Trade + Retail Trade + Other Service Employment[a]	-0.98	0.226
Observations	1,213.0	
Log Likelihood at Zero	-10,066.8	
Log Likelihood at Convergence	-8,214.3	
Rho Squared	0.184	

[a] Size coefficients are exponentiated in the utility calculations. For example, the base office employment size coefficient of 0.0 is applied as exp(0.0) x office employment, or 1.0 x office employment.

Table 5.8 Destination Choice Coefficient Estimates – Recreation Purpose

Variables	Model R3	
Utility Variables	**Coefficient**	**t-stat**
Mode Choice Logsum	0.0500	a
Distance – All (per mile of straight line distances between TAZ centroids)	-0.0129	-33.8
Distance – High-Income (additive to Distance – All)	0.0002	0.8
Distance – Missing Income (additive to Distance – All)	0.0004	0.8
Max (0, Distance-200 miles) (additive to Distance – All)	0.0084	14.1
Max (0, Distance-450 miles) (additive to Distance – All)	-.0057	-2.5
CBD	-0.81	-7.8
CBD Fringe	-1.02	-17.1
Urban	-1.25	-25.0
Suburban	-0.823	-21.8
Accessibility Disney[a]	2.17	26.9
Accessibility Yosemite[a]	1.83	19.8
CBD or CBD Fringe – SACOG	0.415	2.6
CBD – MTC	1.30	11.3
CBD – SANDAG	1.48	11.3
Size Variables	**Coefficient**	**St. Err.**
Log Size Multiplier	1.00	a
Leisure/Hospitality Employment[b]	0.00	a
Transportation Employment[b]	-2.14	0.130
Zonal Area (in square miles)	0.313	0.056
Observations	6,619.0	
Log Likelihood at Zero	-54,693.4	
Log Likelihood at Convergence	-42,736.2	
Rho Squared	0.219	

[a] Accessibility measures were generated using the following formula: $Acc_{ij} = \frac{2}{\max\left(2, Distance_{ij}^{2}\right)}$. Accessibility is measured for zone *i* to attractor *j*, and the distance is the straight-line distance in miles. The accessibility value takes values between 0 and 1, with locations close to the large attractor taking larger values.

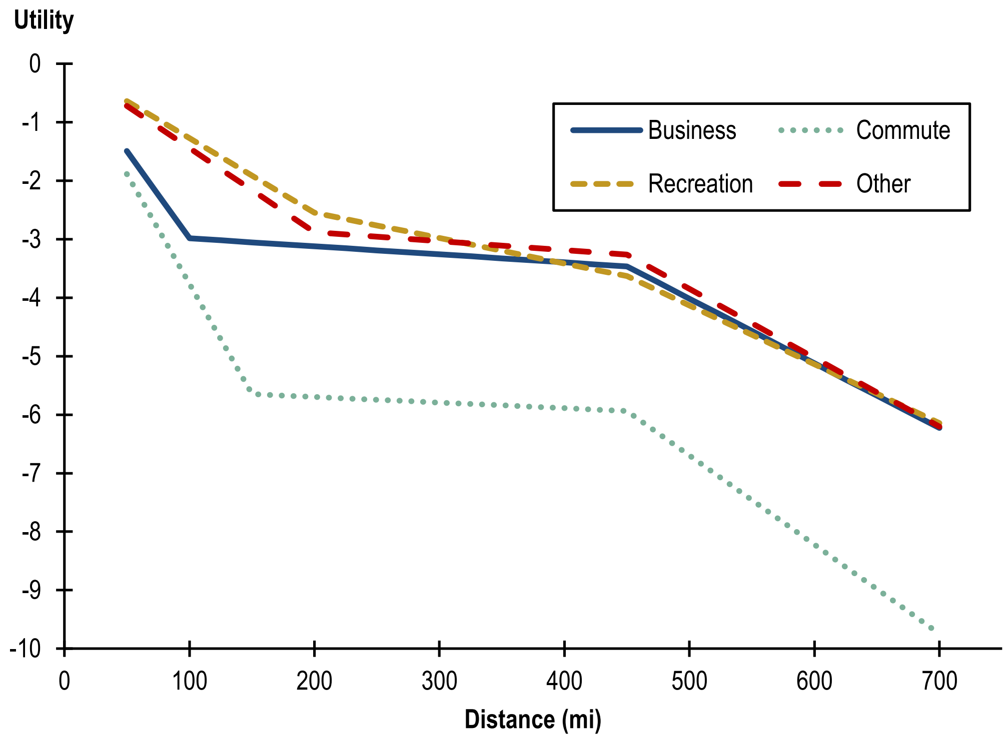
[b] Size coefficients are exponentiated in the utility calculations. For example, the base office employment size coefficient of 0.0 is applied as exp(0.0) x office employment, or 1.0 x office employment.

Table 5.9 Destination Choice Coefficient Estimates – Other Purpose

Variables	Model O3	
Utility Variables	**Coefficient**	**t-stat**
Mode Choice Logsum	0.0500	a
Distance – All (per mile of straight line distances between TAZ centroids)	-0.0157	-50.5
Distance – High-Income (additive to Distance – All)	0.0013	6.5
Distance – Missing Income (additive to Distance – All)	0.0019	5.3
Max (0, Distance-200 miles) (additive to Distance – All)	0.0129	25.5
Max (0, Distance-450 miles) (additive to Distance – All)	-0.0103	-7.0
CBD	-0.232	-3.3
CBD Fringe	-0.296	-7.7
Urban	-0.257	-8.4
Suburban	-0.184	-6.9
CBD or CBD Fringe – SACOG	0.942	10.3
CBD – MTC	0.340	3.8
CBD – SANDAG	0.677	5.5
Size Variables	**Coefficient**	**St. Err.**
Log Size Multiplier	1.00	a
Leisure/Hospitality Employment[a]	0.00	a
Office Employment[a]	-2.79	0.151
Education/Medical Employment[a]	-2.48	0.101
Primary Sector + Wholesale Trade + Transportation + Retail Trade + Other Service Employment[a]	-4.16	0.246
Households[a]	-2.36	0.058
Zonal Area (in square miles) [a]	-0.852	0.126
Observations	10,464.0	
Log Likelihood at Zero	-86,829.4	
Log Likelihood at Convergence	-75,393.6	
Rho Squared	0.132	

[a] Size coefficients are exponentiated in the utility calculations. For example, the base office employment size coefficient of 0.0 is applied as exp(0.0) x office employment, or 1.0 x office employment.

Figure 5.7 Distance Utility Effect on High-Income Utility in Four Estimated Models



Business Model

Table 5.6 shows the estimation results for the business purpose destination choice model. A total of more than 3,600 observations was used in estimation. The model includes a number of statistically significant effects and a good measure of fit was obtained.

- **Distance effects.** There are strong distance effects for the "base" distance variable and some additional differentiation using piecewise linear distance effects and differences by income.

  The piecewise linear distance variables, "Max (0, Distance-100)" and "Max (0, Distance-450)" are additive to the base distance variable. The effect of the piecewise linear distance variable for "Max (0, Distance-100)" almost negates the base distance variable, suggesting that the increasing effect of distance is minimal in the 100- to 450-mile range (Figure 5.1).

- **Income effects** are introduced by using the "Distance – Low-Income," "Distance – High-Income," and "Distance – Missing Income" variables, which also are additive to the base distance variable. The negative coefficient on the low-income variable and positive coefficients on the high- and missing-income variables indicates that low-income individuals are less likely to travel longer distances for business trips compared to medium-income individuals. The reverse is true for high-income individuals and for those with missing income.

- **Land Use effects**. The positive coefficients on the CBD area type variable and the additional CBD effects for SACOG, MTC, and SANDAG regions suggest that all else being equal, zones categorized as CBD are more attractive destinations.

  The SACOG CBD and CBD Fringe are particularly attractive, over and above what is explained by accessibility and size variables. This probably is a function of the State Capitol and government offices at those locations.

  Note that the variables specific to SACOG, MTC, and SANDAG regions are all additive to the base CBD variable. Also, note that under the new area type definitions, no zones outside SACOG, MTC, SCAG, or SANDAG are categorized as CBD.

- **Size effects**. For the business model, it is assumed that each job in a zone should contribute to the size variable for that zone. However, when separate coefficients were estimated for each employment category, wholesale trade and retail trade employment types resulted in highly negative coefficients; meaning they have no effect on the size function since they are exponentiated in application. Therefore, jobs of these employment categories were combined with the transportation employment category, with each job of these employment types contributing the same amount to the overall size variable for a zone.

Commute Model

Table 5.7 shows the estimation results for the commute purpose destination choice model. Despite a smaller sample size that reflects fewer long-distance commute trips, the model again provides statistically significant effects and good overall model fit.

- **Distance effects.** The "base" distance effect is again strong and significant. We also see the piecewise linear distance variables dampening the effect of increasing distance in the middle distance range of 150 to 450 miles (Figure 5.6). Similar to the business model, the commute model includes segmentation of the distance effect by income level. The estimated coefficients suggest that high and missing income individuals are more willing to travel longer distances.

- **Land Use effects.** For the commute purpose, the area type indicators generally did not have significant impacts on the destination choice utilities and were removed.

- **Size effects**. Like the business model, we believe that each job in a zone should contribute to the size variable for that zone in the commute model.

Since several of the employment categories were found to not have significant individual impacts on the size function, those categories were combined (primary sector, wholesale trade, retail trade, and other service employment).

Recreation Model

Table 5.8 presents the destination choice model for the recreation trip purpose. A large sample size of more than 6,600 observations for recreation travel was used in estimation. Strong statistically significant results were obtained for most explanatory variables. The best overall model fit among destination models was obtained.

- **Distance effects.** Similar distance variable effects to those noted for the business and commute models can be noted in the model for recreational travel.
- **Land Use effects.** The area type indicator variables suggest that, all else being equal, MTC and SANDAG CBDs are preferred for long-distance recreational travel. However, the negative coefficients on the base CBD variable and CBD fringe, urban, and suburban area type variables suggest that rural zones also are highly attractive for recreation trips. The SACOG CBD and CBD Fringe are attractive, over and above what is explained by the accessibility and size variables. This is probably a function of the State Capitol and other government offices at those locations.
- **Accessibility effects.** We tested a number of different location-specific accessibility variables, but retained only accessibility to Disneyland and accessibility to Yosemite National Park. Those two locations had the largest t-statistics of the various locations tested and are the two recreation locations most likely to attract travelers for the sole purpose of visiting that location. Other locations such as the Sea World or Fisherman's Wharf also are popular tourist destinations. However, travel to those locations is often combined with visits to other tourist destinations in the regions such as the San Diego Zoo or the Golden Gate Bridge. Therefore, the impacts of recreational sites other than Disneyland and Yosemite should generally be captured through the leisure employment size variables and region-specific area type variables.
- **Size effects.** Unlike the business and commute models, we did not believe that each job should necessarily have an impact on the size function for recreation purposes. In this model, the size function features only the leisure/hospitality employment of the zone, transportation employment of the zone, and the zonal area.

"Other Purpose" Model

Table 5.9 shows coefficient estimates for the "all other purposes" destination choice model. This model has the largest sample size available for estimation (more than 10,400 observations), but has the lower overall model fit, in part, reflecting the range of travel purposes that were considered together.

This model is similar to the other models in terms of the distance effects and the area type effects.

- **Size effects.** For this group of "other purposes," we again required each job to be represented in the size function. The highly negative coefficient on the "catch all" employment category (including primary sector, wholesale trade, transportation, retail trade, and other service employment) implies that the impact of those employment types is quite low for destination choice. The size function also includes zonal area and number of households.

5.3 Trip Frequency Model Estimation

This section details the trip frequency model estimation process and results.

Model Estimation Data

The data used for trip frequency model estimation were derived from the 2012 long-distance travel portion of the CHTS. As discussed in detail in Section 2.2, a number of data issues were identified with the CHTS long-distance data. Table 5.10 summarizes the survey design issues affecting the trip frequency model estimation, along with the methods used to correct the data.

Table 5.10 Trip Purpose Correspondence between Survey and Model

Issue Number	Survey Design Issue	Correction Method
1	Since completion of only the CSHTS Daily Diary was required for a survey to be considered to be complete, only about one-half of the respondent households completed the long-distance travel portion of the survey. Household characteristics and trip-making characteristics for households completing and households failing to complete the long-distance travel portion of the survey were different.	Responses from households completing the long-distance travel component were expanded based on household size, workers per household, number of vehicles, income group, and geographic area to estimates of 2010 households from the CSTDM population synthesis.
2	The long-distance travel portion did not include a "repetition frequency" question, which would have allowed respondents who made multiple long-distance trips to the same location via the same travel mode to quickly report the repeated trips. An analysis of the responses, along with the number of long-distance travel portions with exactly eight trips, suggested that respondent fatigue, coupled with a lack of understanding of the need for respondents to report all long-distance travel, was an important issue.	An imputation process based on information collected in the 2011 Harris Panel Long-Distance Survey performed for the CAHSRA was developed. Repeat factors were imputed based on trip purpose, income level, and trip distance.

Issue Number	Survey Design Issue	Correction Method
3	The long-distance travel portion required respondents to remember and report travel completed as far back as eight weeks prior to their assigned travel day. The recall survey was subject to memory lapses resulting in underreporting of long-distance trips.	Adjustment factors by distance range were applied so that the total expanded long-distance trips by distance range (25-mile increments) matched the total long-distance trips by distance range estimated from the daily diary data.
4	Many respondents failed to record both directions of travel. On average, for every outbound trip, only 65 percent of return trips were recorded.	Information from only the outbound records was used and symmetry of trips was assumed.
5	The long-distance recall survey was not subject to the same rigorous process to make sure that all trips completed by all household members were reported by the survey respondent.	See correction method for Issue Number 3.

Model Estimation Data Set Design

The CHTS long-distance data set provided the information necessary to estimate control totals for the trip frequency model calibration. However, different data were required for model estimation. The CHTS long-distance data set included one record for each "unique trip" reported by a member of the household. If multiple household members made the trip, that information was posted on the record, but the trip record was not repeated for each household member. Further, we had to account for, and take advantage of, the fact the long-distance travel data included all long-distance trips made by a household over an eight-week period, not just a single day.

For model estimation, a data set was created that showed the number of days each person made 0 trip, 1 trip, or 2 or more trips during the eight-week, 56-day recall period. For example, during the 56-day recall period for the business trip purpose, a single person might have had: 53 days with 0 trip; 2 days with 1 trip; and 1 day with 2 trips (i.e., one round-trip).

The information for that person was represented by three trip records: one for 0 trip with a weight of 53; one for 1 trip and a weight of 2; and one for 2 trips with a weight of 1.

A complicating factor with the development of the estimation data set was that only 65 percent of the outbound trips could be matched to a return inbound trip. As with the procedures used to develop the control totals for long-distance trips, only outbound trips were included in the model estimation data set base, and symmetry was assumed for the inbound trip. In order to include information on persons making one or two trips per day, we needed to know whether the symmetrical inbound trip was made on the same day as the outbound trip, or whether the inbound trip occurred on a subsequent day. Three following three options were considered to resolve this issue:

- **Option 1.** For the 65 percent of trips with both outbound and inbound trips reported, whether the inbound trip occurred on the same day could be directly found by comparing the dates on the two trips. For the remaining 35 percent of trips, this could be imputed based on trip lengths, number of household members traveling, and other information.
- **Option 2**. Since it had been determined that the Version 2.0 model would not model trip duration, we could simply view the long-distance person days for trip frequency as a 0-1 variable for "did not make a long-distance trip" or "made a long-distance trip." In effect, this simplified the trip frequency model from the Version 1 model multinomial model with choice options of 0, 1, or 2+ trips on a given day to a binary choice model. In the example above, the four business trips made by the individual (i.e., one roundtrip with the outbound and inbound trips occurring on different days and one roundtrip with the trips occurring on the same day) could be represented as two outbound trips in the dataset. Each of these trips would be assumed to have a symmetrical inbound trip. Thus, for the 56-day recall period, we would model the four trips as four person-days of travel and 52 no-travel days. While this would be in contrast to what actually occurred (53 no-travel days and three travel days, one of which included two trips), the correct number of person trips would be represented.
- **Option 3**: The decision-making unit could be changed to the household. Similar to option 2, whether the inbound trip occurred on the same day or not would not be directly modeled. Instead, the total number of outbound long-distance trips for the entire household on a given day would be the dependent variable, and given a weight of two (to account for the return inbound trip). While this approach would simplify the creation of the estimation data set, it would complicate the trip frequency model, since the total number of possible trips generated in a day for a household would be equal to the household size.

Option 2 was chosen for a couple of reasons. First, Option 3 would have unnecessarily complicated the trip frequency model. Second, the simplicity of the binary choice model (make one trip or make no trips) was appealing. Further, the Version 1.0 models only differentiated the utility of 1-trip versus 2-trip alternatives via the alternative-specific constants. We did not believe there would be much opportunity to improve upon that part of the Version 1.0 models, and if the only difference would be a constant, it did not seem worth treating those choices differently. Finally, by moving to a choice of travel versus no travel, it was relatively simple to further distinguish the travel alternatives between traveling alone or in a group.

Another consideration in the decision to use Option 2 was that moving to a binary choice for a person-day would not preclude the later addition of a trip duration model. It could be argued that such a model should be partially dependent upon the distance traveled and, thus, applied after destination choice. It would not really change the number of trips modeled on a given day. Rather, it would simply add information regarding the duration of a trip that could then be used for the estimation of parking costs for mode choice.

Development of Final Trip Frequency Model Estimation Data Set

A family of data sets (one for each trip purpose) based on Option 2 was created for model estimation. The following adjustments were made:

- Only outbound (P→A) trips were included in the dataset. It was assumed that inbound (A→P) trips are symmetrical.
- Repeat factors found in the data were used to determine the total number of trips made by a household. Repeat factors indicated the number of times each unique trip record was made during the 56-day recall period. Since the repeat factors were not collected for the long-distance portion of the CHTS, they were imputed using information from the 2011 Harris Long-distance survey.
- Each household was represented three separate times in the dataset for each trip purpose: once for the "No Travel" alternative; once for the "Travel Alone" alternative; and once for the "Group Travel" alternative. Representative weights for each of the three alternatives were based, in part, on the number of days during the recall period for which each alternative was chosen.
- Since, in keeping with the Version 1 model form, it was determined that the trip frequency model would continue to be a person-based model, household size was further used to weight the data. For the example above, if the household had been a 2-person household with the second person accompanying the first person for all travel, 52 no travel days, 0 alone travel day, and 4 group travel days would have been recorded for the person.
- Group travel was determined by the existence of reported traveling companions, whether or not the companions were from the same household.
- Households reporting no trips for the 56-day recall period were included in the estimation data set as 56 no travel days for each of the four trip purposes, and zero alone and zero group travel days for each of the four trip purposes.

Based on the design of the data set, a multinomial choice model could be constructed for each trip purpose with the choices being: make zero trips, make one trip alone, make one trip in a group. The make one trip alone and make one trip in a group included alternative-specific constants that could be adjusted to match control totals for all intra-California, long-distance trip-making on a given day.

Trip Frequency Model Estimation Data Set Summary Statistics

Table 5.11 summarizes the data and choices included in the trip frequency model estimation data set.

Table 5.11 Trip Frequency Model Estimation Dataset Statistics

Trip Purpose	Business	Commute	Recreation	Other
No Travel Days	53,070	52,979	52,640	52,461
Travel Alone Days	118	245	46	139
Travel in Group Days	132	95	633	719
Total Number of Person Days[a]	**53,319**	**53,319**	**53,319**	**53,319**
No Travel Days	99.53%	99.36%	98.73%	98.39%
Travel Alone Days	0.22%	0.46%	0.09%	0.26%
Travel in Group Days[a]	0.25%	0.18%	1.19%	1.35%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**

[a] Totals may not sum due to rounding.

Trip Frequency Model Design

The trip frequency model includes the following key features:

1. Trip frequency for each trip purpose (business, commute, recreation, and other) is handled in separate models. All trips greater than 50 miles (measured as straight-line distance from TAZ centroid-to-centroid) are considered long-distance trips.
2. The model choice set includes the decision to make 0 trip, 1 travel alone trip, and 1 travel in a group trip for each individual member of a household on a specific day. Since the trip frequency model will explicitly model group size, a separate group size submodel is not needed.
3. The formulation of the short-distance accessibility variable used in the latest models is shown below.

$$Acc_i = \ln\left(1 + \sum_{j \in B_i} \frac{(Emp\ or\ Emp + HHs)_j}{\exp\left(-2 \times \frac{Dst_{ij}}{Dst_{mean}}\right)}\right)$$

   This function reflects the characteristic that greater numbers of short-distance opportunities will result in individuals generating fewer long-distance trips to satisfy their activity needs. Dst in the denominator of the summation is the straight-line distance to ensure changes to the highway network will not affect the accessibility variable, which could potentially lead to undesired results when the model is applied. B_i represents the set of TAZs that are less than 50 miles (i.e., short-distance) from zone i.

4. Like the Version 1.0 models, destination choice logsums are included in the models reflecting the characteristic that increased accessibility to destinations more than 50 miles from a traveler's home will result in increased long-distance trip-making (or vice versa). Changes in the destination choice logsum values can result from changes in travel impedances from the TAZ in

question to all other TAZs in the State (e.g., due to the introduction of a high-speed rail system) or changes in households and employment throughout the State.

5. Household size, income level, number of workers, and auto availability socioeconomic variables have continued to be included in the Version 2.0 models.

Estimation Results

For each of the four trip purposes, the alternatives in the models are identical and include no long-distance trips, 1 travel-alone long-distance trip, and 1 travel-in-group long-distance trip. The no-travel alternative represents the reference alternative and always has utility equal to zero. Nested logit models were tested for each trip purpose, where the nest in each case contained the two travel alternatives with the no-travel alternative outside the nest. In the case of commute and recreation models, the estimated nesting coefficients were not significantly different from 1.0 and/or greater than 1.0. In the other two models, the estimated nesting coefficients were reasonable, but did not improve the fit of either model significantly. Therefore, all recommended models shown below are multinomial logit models.

Table 5.12 shows the estimation results for the business and commute purpose models. For each of these two models, the zonal attribute used in computing the short-distance accessibility variables was the total employment. For the commute model, the initial, unconstrained coefficient estimate of the long-distance destination choice logsum was greater than 1.0. Since this was an illogical result, it was constrained to 1.0 for the final estimation of the model.

Overall, the two models have similar trends in the estimated coefficients. Most of the demographic variables have similar effects on the utilities of traveling alone or in a group. For instance, larger households were found to make fewer trips, in general, but were less likely to travel alone than in a group, though this effect is dampened for each worker in the household. Households with no workers are less likely to make business trips or, especially, commute trips.

Table 5.12 Business and Commute Trip Frequency Model Estimation Results

Variable	Business		Commute	
	Coefficient	t-statistic	Coefficient	t-statistic
Long-Distance Destination Choice Logsum – Business	0.799	4.3		
Long-Distance Destination Choice Logsum – Commute			1.00	
Short-Distance Accessibility (Total Employment) – All	-0.192	-4.9	-0.247	-6.6
ASC – Alone	-12.1	-5.3	-11.5	-17.8
Household Size – Alone	-0.582	-5.9	-0.382	-5.7
Cars less than Workers – Alone			-1.031	-2.3
ASC – Group	-12.7	-5.5	-12.7	-18.3
Household Size – Group	-0.329	-3.6	-0.302	-2.9
Cars less than Workers – Group	0.263	0.7		
High-Income – Alone/Group	0.209	1.4		
Workers – Alone/Group	0.217	1.5	0.337	2.8
No Workers in Household – Alone/Group	-0.468	-1.4	-1.28	-3.5
Observations	53,319		53,319	
Log Likelihood – Constants Only	-1,757.4		-2,261.4	
Log Likelihood at Convergence	-1,706.9		-2,169.9	
Rho-Squared	0.029		0.040	

Table 5.13 shows the estimated results for the recreation and other purpose models. Unlike the business and commute models, the short-distance accessibility variables for these two models are different. For the recreation model, leisure employment in the accessibility variable was used rather than total employment. For the other model, the average of accessibility variables computed for leisure employment and for households was used.

The effects of demographic variables in the recreation and other purpose models are similar, like the business and commute models. For instance, larger households are much less likely to generate trips traveling alone. In addition, low-income households are less likely to generate trips overall, while high-income households are more likely to generate trips.

The alternative-specific constants are relatively large for each of the four models. As noted by the RTAP, the very large alternative-specific constants in the model are considered to be appropriate and reflect the fact that long-distance trips are infrequently made by people. Based on the expanded CSHTS data, residents of California make about 1/100th as many long-distance trips as short-distance, local trips on an average day.

Table 5.13 Recreation and Other Trip Frequency Model Estimation Results

	Recreation		Other	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
Long-Distance Destination Choice Logsum – Recreation	0.478	3.0		
Long-Distance Destination Choice Logsum – Other			0.463	4.2
Short-Distance Leisure Employment Accessibility – All	-0.032	-1.2		
Short-Distance Accessibility (0.5*Leisure Emp. + 0.5*Households) – All			-0.186	-8.1
ASC – Alone	-9.9	-5.4	-6.20	-4.9
Household Size – Alone	-0.944	-5.7	-1.01	-10.1
ASC – Group	-9.7	-5.4	-6.90	-5.5
Household Size – Group			-0.0641	-1.6
Low-Income – Alone/Group	-0.570	-3.5	-0.226	-1.9
High-Income – Alone/Group	0.373	3.8	0.076	0.9
Missing Income – Alone/Group	0.135	0.8	-0.356	-2.2
No Cars – Alone/Group			-0.586	-1.9
Workers – Alone/Group			-0.129	-2.4
Observations	53,319		53,319	
Log Likelihood – Constants Only	-3,806.8		-4,773.1	
Log Likelihood at Convergence	-3,757.2		-4,661.8	
Rho-Squared	0.013		0.023	

Model Application

The estimated models produce the probabilities of a single person in a household making 1 travel-alone long-distance trip and 1 travel-in-group long-distance trip on a given day. Since the P→A trips were, in effect, doubled in the estimation data set to represent the symmetrical A→P trips (see the example under the Option 2 discussion above), the probabilities represent the trips per person for each household type. The trips per person will be multiplied by the household size and, then by the number of households in the specific household size group to estimate the total person trips "generated."

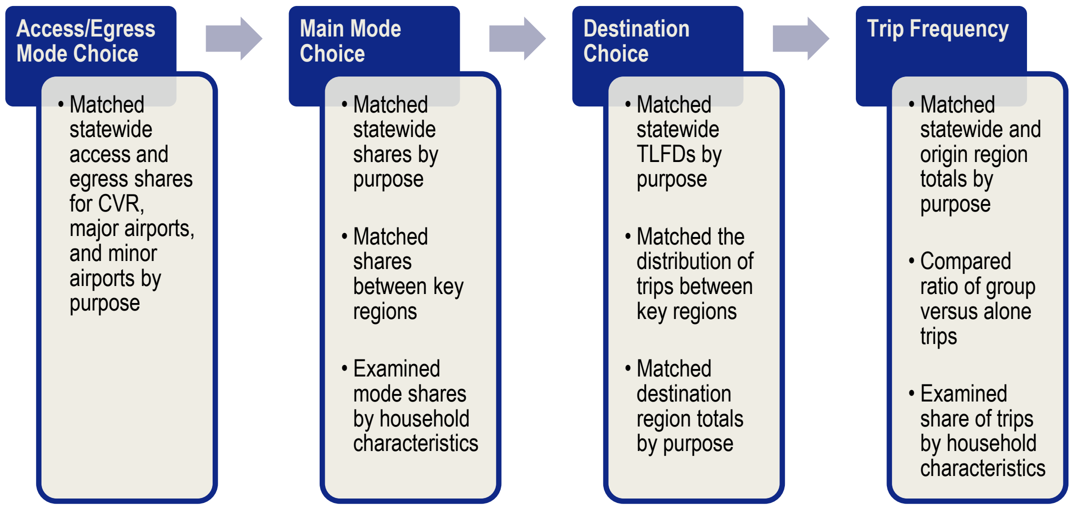
6.0 Long-Distance Model Calibration

6.1 Overview of Calibration Process

The Version 2.0 models, including trip frequency, destination choice, main mode choice, and access/egress mode choice, were calibrated to reproduce estimates of long-distance travel patterns of California travelers. The observed data were based on an expansion of the 2012/2013 CHTS Daily Diary and Long-Distance survey data to match the socioeconomic characteristics of the 2010 California population. The expansion of 2012/2013 CHTS data to year 2010 conditions is documented in Section 2.2.

Since the model components pass logsum information "up" through the modeling process and trip information "down" through the process, the individual model components had to be calibrated in an iterative fashion. We began by calibrating the access/egress portion of the mode choice model followed by, and sometimes simultaneously with, the main mode portion of the mode choice model. Once calibration targets were reached for access/egress and main mode choice models, we moved on to destination choice, followed by trip frequency. We then repeated the process, since individual adjustments to one model can have unintended consequences on others. Figure 6.1 illustrates this iterative process we took toward calibration and documents the targets we focused on matching for each model. The next several sections detail the calibration results for each model.

Figure 6.1 Calibration Process



6.2 Access/Egress Mode Choice Model Calibration

Access/Egress Calibration Targets

Unlike most of the other calibration targets that will be discussed in Section 6.0, the access/egress target shares did not come from the CHTS survey. Instead, target shares were developed from observed data from available sources.

Air access and egress shares were derived from two sources of data:

1. MTC 2006 airline passenger survey tabulations of access and egress modes at Oakland and San Francisco airports; and
2. 2005 RP/SP survey.

CVR access and egress shares were developed from three sources of data:

1. 2007 Capitol Corridor Satisfaction Study;
2. Summaries of ridership data for San Diego area conventional rail services; and
3. 2005 RP/SP survey.

In addition to these data sources, professional judgment was used to develop the final access and egress mode share targets by trip purpose. Moreover, early on in examining these data sources, it became evident that access and egress mode shares were quite different at airports and CVR stations. Major and minor airports had starkly different access and egress modal shares as well. Because the model was not developed to allow for these sorts of differences explicitly, additional constants were added to the models. These constants allowed for calibration to separate CVR station targets, major airport targets, and minor airport targets.

Major airports include the following:

- Los Angeles International (LAX);
- John Wayne (SNA);
- Burbank (BUR);
- Ontario (ONT);
- Long Beach (LGB);
- San Diego (SAN);
- San Francisco (SFO);
- San Jose (SJC);
- Oakland (OAK); and
- Sacramento (SMF).

Minor airports include the following:

- Monterey (MRY);
- Oxnard (OXR);
- Palm Springs (PSP);
- Santa Barbara (SBA);
- Arcata (ACV);
- Bakersfield (BFL);
- Fresno (FAT); and
- Modesto (MOD).

Table 6.1, Table 6.2, and Table 6.3 show the calibration targets and final access and egress mode share for major airports, minor airports, and CVR stations, respectively. For the purposes of forecasting HSR ridership, the HSR modal access and egress models use the constants calibrated for CVR stations.

Table 6.1 Access and Egress Mode Shares to Major Airports by Aggregated Trip Purposes

Region	Target Mode Shares						Calibrated Model Mode Shares					
	Park	Rental Car	Drop-off/ Pick-up	Taxi	Transit	Walk/ Bike	Park	Rental Car	Drop-off/ Pick-up	Taxi	Transit	Walk/ Bike
Business												
Commute – Access	45%	0%	30%	15%	10%	0%	45%	0%	30%	15%	10%	0%
Commute – Egress	0%	40%	15%	35%	10%	0%	0%	40%	15%	34%	10%	0%
Recreation												
Other – Access	25%	0%	45%	15%	15%	0%	24%	0%	46%	13%	17%	0%
Other – Egress	0%	25%	45%	20%	10%	0%	0%	25%	45%	19%	11%	0%

Table 6.2 Access and Egress Mode Shares to Minor Airports by Aggregated Trip Purposes

Region	Target Mode Shares						Calibrated Model Mode Shares					
	Park	Rental Car	Drop-off/ Pick-up	Taxi	Transit	Walk/ Bike	Park	Rental Car	Drop-off/ Pick-up	Taxi	Transit	Walk/ Bike
Business												
Commute – Access	80%	0%	15%	2%	3%	0%	77%	0%	14%	6%	3%	0%
Commute – Egress	0%	57%	20%	20%	3%	0%	0%	54%	20%	20%	6%	0%
Recreation												
Other – Access	45%	0%	50%	2%	3%	0%	50%	0%	46%	1%	3%	0%
Other – Egress	0%	20%	70%	5%	5%	0%	0%	30%	54%	9%	7%	0%

Table 6.3 Access and Egress Mode Shares to CVR Stations by Aggregated Trip Purposes

Region	Target Mode Shares						Calibrated Model Mode Shares					
	Park	Rental Car	Drop-off/ Pick-up	Taxi	Transit	Walk/ Bike	Park	Rental Car	Drop-off/ Pick-up	Taxi	Transit	Walk/ Bike
Business												
Commute – Access	75%	0%	10%	1%	9%	5%	75%	0%	9%	1%	9%	5%
Commute – Egress	0%	1%	10%	30%	50%	9%	0%	2%	52%	4%	27%	16%
Recreation												
Other – Access	35%	0%	33%	2%	10%	20%	33%	0%	36%	1%	9%	20%
Other – Egress	0%	2%	51%	5%	26%	16%	0%	2%	52%	4%	27%	16%

Access/Egress Calibration Results

The access/egress model constants were adjusted in order that the final 2010 model achieved results within a reasonable tolerance to the calibration targets, as described above. The final calibrated constants are shown in Table 6.4 and Table 6.5 for business/commute and recreation/other trip purposes, respectively. In each table, the initial constants developed during model estimation are shown alongside the calibrated constants. Also calculated is the value of the calibrated constants in terms of equivalent minutes of access/egress travel time (based on the coefficients associated with access/egress travel time in each model).

Table 6.4 Access-Egress Mode Choice Model Constants – Business/Commute

Access/ Egress Mode		Main Mode	Initial Constants	Calibrated Constants	Equivalent Minutes
Drive and Park	Access	All	1.047	2.289	-151
		Air – Major Airports		-1.357	89
		Air – Minor Airports		-0.084	6
Rental Car	Egress	All	0.547	0.833	-55
		Air – Major Airports		0.222	-15
		Air – Minor Airports		0.305	-20
Taxi	Access	All	-0.466	-1.741	115
		Air – Major Airports		1.455	-96
		Air – Minor Airports		0.398	-26
	Egress	All	0.312	1.75	-115
		Air – Major Airports		-0.48	32
		Air – Minor Airports		-0.99	65
Transit	Access	All	0.338	1.659	-109
		Air – Major Airports		-0.943	62
		Air – Minor Airports		-0.372	24
	Egress	All	1.326	3.517	-231
		Air – Major Airports		-2.473	163
		Air – Minor Airports		-3.282	216
Walk	Both	CVR and HSR Only	1.065	2.885	-190

Table 6.5 Access-Egress Mode Choice Model Constants – Recreation/Other

Access/ Egress Mode		Main Mode	Initial Constants	Calibrated Constants	Equivalent Minutes
Drive and Park	Access	All	-0.089	-0.24	29
		Air – Major Airports		-0.462	56
		Air – Minor Airports		-0.121	15
Rental Car	Egress	All	-0.61	0.017	-2
		Air – Major Airports		-0.817	100
		Air – Minor Airports		-1.474	180
Taxi	Access	All	-0.478	-2.548	311
		Air – Major Airports		1.608	-196
		Air – Minor Airports		-0.144	18
	Egress	All	-0.527	-1.777	217
		Air – Major Airports		1.206	-147
		Air – Minor Airports		-0.144	18
Transit	Access	All	0.316	0.526	-64
		Air – Major Airports		-0.378	46
		Air – Minor Airports		-1.194	146
	Egress	All	0.5	1.504	-183
		Air – Major Airports		-1.925	235
		Air – Minor Airports		-2.301	281
Walk	Access	CVR and HSR Only	0.501	2.439	-297
	Egress	CVR and HSR Only	0.733	1.222	-149

6.3 Main Mode Choice Model Calibration

Main Calibration Targets

For main mode choice model calibration, the key targets came from the CHTS statewide modal shares by trip purpose. While the primary targets were statewide mode shares, origin region mode shares also were checked between the CHTS targets and model. In most cases, the regional mode shares were close to targets, even if they did not match as well as statewide numbers. The origin region results are characterized by the region in which a trip originated.

Table 6.6, Table 6.7, Table 6.8, and Table 6.9 show the main mode calibration targets by origin region and the State for each trip purpose. In addition, calibrated model shares are shown in the table for comparison purposes. As illustrated in the tables, the model shares at the statewide level are nearly identical to the targets. At the origin region level, there is more variation with some regions matching targets better than others, but overall, even the regional model shares match targets relatively well.

Table 6.6 Main Mode Calibration Targets and Model Shares by Origin Region – Business Purpose

	CHTS				Calibrated Model				Percent Difference			
Region Name	**CAR**	**AIR**	**CVR**	**Total**	**CAR**	**AIR**	**CVR**	**Total**	**CAR**	**AIR**	**CVR**	**Total**
SACOG	6,595	545	230	7,369	6,744	562	100	7,407	2%	3%	-56%	1%
SANDAG	9,030	654	264	9,948	8,756	1,091	150	9,997	-3%	67%	-43%	0%
MTC	24,886	3,959	615	29,460	26,459	2,669	463	29,591	6%	-33%	-25%	0%
SCAG	58,275	4,519	695	63,489	57,362	5,179	1,156	63,698	-2%	15%	66%	0%
San Joaquin Valley	21,709	290	121	22,120	21,204	724	251	22,179	-2%	150%	107%	0%
Other	14,385	639	89	15,112	14,490	554	146	15,191	1%	-13%	65%	1%
Total	**134,881**	**10,606**	**2,014**	**147,500**	**135,014**	**10,780**	**2,267**	**148,062**	**0%**	**2%**	**13%**	**0%**

Table 6.7 Main Mode Calibration Targets and Model Shares by Origin Region – Commute Purpose

	CHTS				Calibrated Model				Percent Difference			
Region Name	**CAR**	**AIR**	**CVR**	**Total**	**CAR**	**AIR**	**CVR**	**Total**	**CAR**	**AIR**	**CVR**	**Total**
SACOG	10,678	15	547	11,240	11,070	34	138	11,242	4%	124%	-75%	0%
SANDAG	24,119	94	1,148	25,361	24,802	133	431	25,366	3%	41%	-62%	0%
MTC	49,608	167	110	49,886	48,955	201	738	49,894	-1%	20%	568%	0%
SCAG	95,494	310	414	96,218	94,178	282	1,774	96,234	-1%	-9%	329%	0%
San Joaquin Valley	32,962	0	0	32,962	32,599	14	356	32,968	-1%	100%	100%	0%
Other	18,374	33	0	18,407	18,204	19	188	18,412	-1%	-42%	100%	0%
Total	**231,235**	**620**	**2,219**	**234,074**	**229,808**	**681**	**3,626**	**234,115**	**-1%**	**10%**	**63%**	**0%**

Table 6.8 Main Mode Calibration Targets and Model Shares by Origin Region – Recreation Purpose

	CHTS				Calibrated Model				Percent Difference			
Region Name	**CAR**	**AIR**	**CVR**	**Total**	**CAR**	**AIR**	**CVR**	**Total**	**CAR**	**AIR**	**CVR**	**Total**
SACOG	31,950	292	101	32,343	31,696	338	303	32,337	-1%	16%	199%	0%
SANDAG	39,921	504	363	40,788	39,745	548	489	40,782	0%	9%	35%	0%
MTC	104,799	2,064	1,026	107,889	104,954	1,797	1,118	107,870	0%	-13%	9%	0%
SCAG	216,088	1,745	2,528	220,361	215,471	2,474	2,341	220,286	0%	42%	-7%	0%
San Joaquin Valley	70,633	137	278	71,048	70,243	175	577	70,996	-1%	28%	108%	0%
Other	30,607	234	175	31,017	30,644	140	231	31,015	0%	-40%	32%	0%
Total	**493,999**	**4,976**	**4,471**	**503,446**	**492,754**	**5,473**	**5,059**	**503,286**	**0%**	**10%**	**13%**	**0%**

Table 6.9 Main Mode Calibration Targets and Model Shares by Origin Region – Other Purpose

	CHTS				Calibrated Model				Percent Difference			
Region Name	**CAR**	**AIR**	**CVR**	**Total**	**CAR**	**AIR**	**CVR**	**Total**	**CAR**	**AIR**	**CVR**	**Total**
SACOG	33,157	520	671	34,347	33,221	695	423	34,339	0%	34%	-37%	0%
SANDAG	41,917	1,604	776	44,297	42,476	1,207	603	44,285	1%	-25%	-22%	0%
MTC	103,942	4,062	927	108,931	104,285	3,089	1,525	108,900	0%	-24%	65%	0%
SCAG	256,012	3,606	2,106	261,724	253,420	4,856	3,402	261,677	-1%	35%	62%	0%
San Joaquin Valley	99,624	210	1,665	101,500	100,046	313	1,107	101,466	0%	49%	-34%	0%
Other	65,821	217	1,013	67,051	65,785	585	654	67,023	0%	169%	-35%	0%
Total	**600,473**	**10,219**	**7,158**	**617,851**	**599,232**	**10,744**	**7,714**	**617,690**	**0%**	**5%**	**8%**	**0%**

CVR Calibration

For the CVR mode, the final mode share targets were adjusted from the summarized CHTS targets, because the initial assignments of CVR trips produced substantially lower CVR volumes than counts reported by operators for a number of key regional pairs. As a result, it was assumed that the observed long-distance CVR trips estimated using the CHTS data were low. Table 6.10 shows the comparison of daily CVR ridership values between key regions.

Table 6.10 Comparison of Average Daily Interregional CVR Ridership for 2010

Regions	Route(s)	Observed Riders[a]	CHTS	Calibrated Model
SANDAG-SCAG	Pacific Surfliner	4,345	3,951	4,161
SACOG-MTC	Capitol Corridor	3,641	2,672	1,898
SJV-MTC	ACE, San Joaquin	2,418	232	1,397
MTC-SCAG	Coast Starliner	538	600	154
SJV-SACOG	San Joaquin	316	336	228
Total between key regions		11,259	7,790	7,838
Other region pairs			8,071	10,239
Total			**15,862**	**18,077**

[a] Includes both long-distance and short-distance riders.

The riders in Table 6.10 were summarized from ridership counts on specific routes. They include all trips crossing regional borders (e.g., SANDAG/SCAG). It was impossible to exclude trips less than 50 miles from these counts. The CHTS data include only long-distance trips (to locations 50 miles or more from the trip-maker's home). The extended long-distance trips were assigned to the modeled network. Calibrated model results shown in Table 6.10 are from the final calibrated model and include only long-distance trips.

Air Calibration

The initial modeled air mode shares for key region pairs were very low, including SCAG-to-MTC, SCAG-to-SACOG, and MTC-to-SANDAG. To correct for this issue, constants were added for access/egress to/from major airports. This ensured that the mode shares for these regional pairs matched targets reasonably well. The list of major airports is identical to the major airports identified in the access/egress mode choice calibration model. Table 6.11 shows the calibration targets and the calibrated model results for region-to-region pairs. Shown in bold are the region pairs of specific interest in the air market.

Table 6.11 Calibration Targets and Results for Region-to-Region Pairs

OD Major Flows	CHTS			Calibrated Model			Difference		
	Auto	Air	CVR	Auto	Air	CVR	Auto	Air	CVR
Intra-SCAG	99%	0%	1%	98%	0%	2%	-1%	0%	1%
Intra-MTC	99%	0%	1%	98%	0%	2%	-1%	0%	1%
Intra-SJV	98%	0%	2%	99%	0%	1%	1%	0%	-1%
Intra-SACOG	100%	0%	0%	99%	0%	1%	-1%	0%	1%
Intra-SANDAG	100%	0%	0%	99%	0%	1%	-1%	0%	1%
Intra-Other	99%	0%	0%	100%	0%	0%	0%	0%	0%
SCAG to SANDAG	98%	0%	2%	98%	1%	2%	-1%	0%	0%
SCAG to SJV	99%	1%	0%	98%	1%	1%	-1%	1%	0%
SCAG to MTC	69%	30%	1%	73%	26%	0%	5%	-4%	-1%
SCAG to SACOG	75%	24%	0%	75%	24%	0%	0%	0%	0%
SCAG to Other	96%	1%	2%	96%	3%	1%	0%	2%	-2%
MTC to SANDAG	49%	49%	2%	55%	45%	0%	6%	-5%	-1%
MTC to SJV	99%	0%	1%	98%	0%	1%	0%	0%	0%
MTC to SACOG	98%	0%	2%	98%	0%	2%	0%	0%	-1%
MTC to Other	99%	0%	1%	99%	0%	1%	0%	0%	0%
SJV to SANDAG	96%	3%	1%	94%	5%	1%	-2%	2%	0%
SJV to SACOG	99%	0%	1%	99%	0%	1%	0%	0%	0%
SJV to Other	100%	0%	0%	99%	0%	1%	0%	0%	0%
SACOG to SANDAG	73%	27%	0%	58%	42%	0%	-16%	16%	0%
SACOG to Other	100%	0%	0%	99%	0%	1%	-1%	0%	1%
SANDAG to Other	90%	5%	5%	88%	11%	1%	-2%	6%	-4%
Total	**97%**	**2%**	**1%**	**97%**	**2%**	**1%**	**0%**	**0%**	**0%**

Final Calibrated Constants

Table 6.12 and Table 6.13 show the estimated model coefficients versus calibrated model coefficients for the business/commute and recreation/other models, respectively. In addition, equivalent minutes of travel time for the calibrated constants is shown as well (based on the in-vehicle time coefficient of the models).

The effects of constants are additive based on purpose, airport access, and airport egress combinations. For example, the business purpose constant for conventional rail is -6.483, while the commute purpose constants for conventional rail is -8.477. As described above, additional constants were added to the model during calibration reflecting access or egress at major airports (rather than minor airports). Similar to the commute-specific constants, these constants are additive to the base air constant. For example, the business purpose constant for air travel between to minor airports is -14.436, for air travel from a major to a minor airport is -12.286, for air travel from a minor to a major airport is -8.244, and for air travel between two major airports is -6.094.

Table 6.12 Estimated and Calibrated Main Mode Choice Model Coefficients – Business/Commute

Mode	Purpose	Initial Constants	Calibrated Constants	Equivalent Minutes
Air	Both purposes	-3.504	-14.436	1,424
	Commute	-1.667	-6.227	614
Conventional Rail	Both purposes	-4.902	-6.483	639
	Commute	-0.505	-1.994	197
Air	Major Airport – Production – Both purposes	N/A	2.150	-212
	Major Airport – Attraction – Both purposes	N/A	6.192	-611

Table 6.13 Estimated and Calibrated Main Mode Choice Model Coefficients – Recreation/Other

Mode	Purpose	Initial Constants	Calibrated Constants	Equivalent Minutes
Air	Both	-1.734	-9.160	1,348
Conventional Rail	Both	-2.973	-3.746	551
Air	Major Airport – Access – Both purposes	N/A	3.632	-534
	Major Airport – Egress – Both purposes	N/A	3.569	-525

6.4 DESTINATION CHOICE MODEL CALIBRATION

The destination choice model is a multinomial logit model, with alternatives defined as TAZs. The destination choice probability calculations are composed of two key components: 1) the utility function (common to all of the choice models in the model system), and 2) the size function. The size function measures the opportunity in an elemental zonal alternative (e.g., number of jobs); whereas, the utility function measures the quality of the zonal alternative (e.g., accessibility). In model calibration, only utility function coefficients were adjusted.

Trip Length Frequencies

Trip length frequency targets were generated from CHTS data by trip purpose. Trip lengths were measured by straight-line distance from origin TAZ centroid to destination TAZ centroid. The destination choice models include a stepwise linear distance curve in the utility function, which allowed the marginal effect of one additional mile of travel to differ within different distance bands. The distance bands varied by trip purpose as follows:

- **Business purpose:**
  - 50 to 100 miles;
  - 100 to 450 miles; and
  - 450 or more miles.
- **Commute purpose:**
  - 50 to 150 miles;
  - 150 to 450 miles; and
  - 450 or more miles.
- **Recreation purpose:**
  - 50 to 200 miles;
  - 200 to 450 miles; and
  - 450 or more miles.
- **Other purpose:**
  - 50 to 200 miles;
  - 200 to 450 miles; and
  - 450 or more miles.

During calibration, the coefficients were adjusted on these distance bands to match the CHTS trip length frequency distributions. Figure 6.2, Figure 6.3, Figure 6.4, and Figure 6.5 show the trip length frequency comparisons between CHTS targets and the final calibrated destination choice model for business, commute, recreation, and other trip purposes, respectively. In general, the trip length frequency distributions match quite well. Because the marginal utility contribution only varies across three travel distance ranges, distributions could not be matched exactly.

Figure 6.2 Trip Length Frequency Distribution Targets and Calibrated Model – Business Purpose

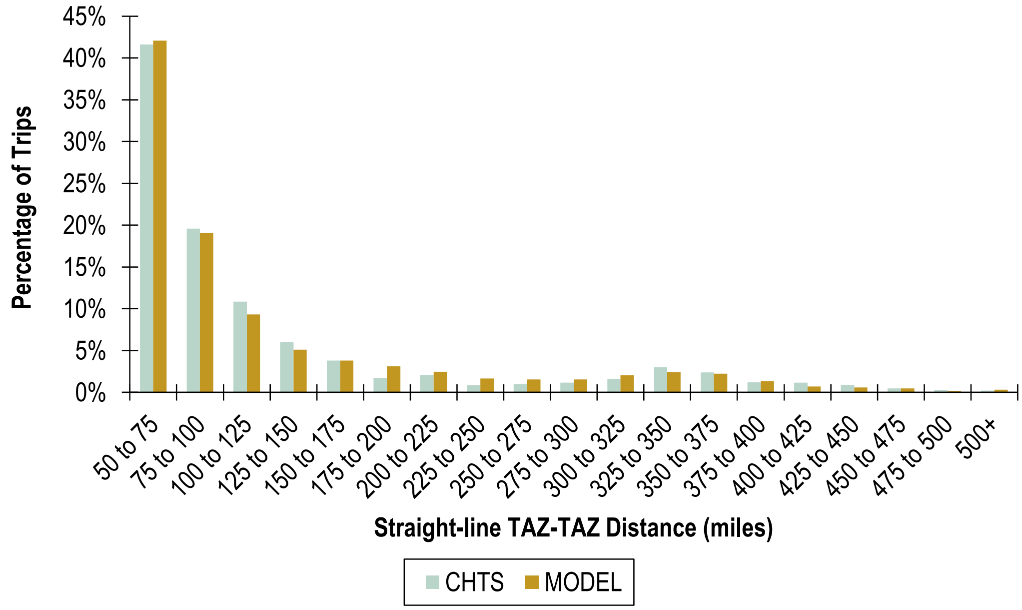


Figure 6.3 Trip Length Frequency Distribution Targets and Calibrated Model – Commute Purpose

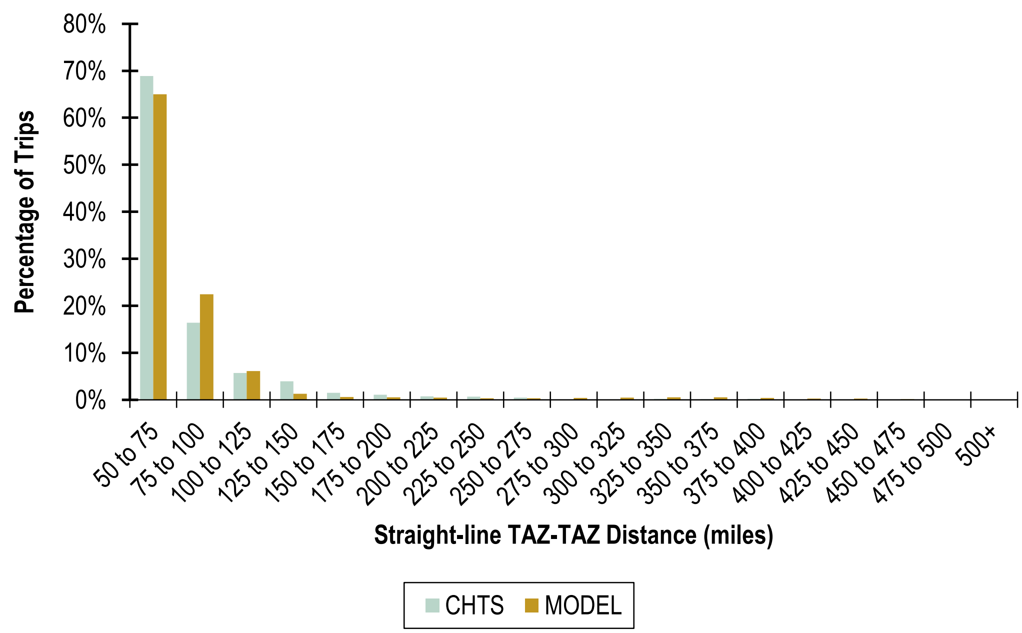


Figure 6.4 Trip Length Frequency Distribution Targets and Calibrated Model – Recreation Purpose

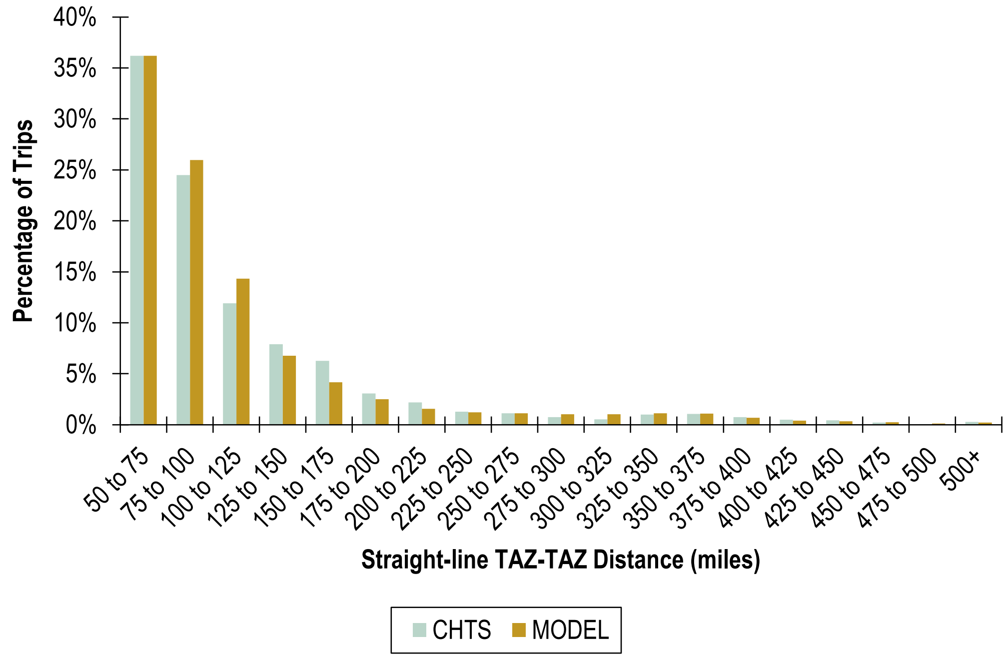
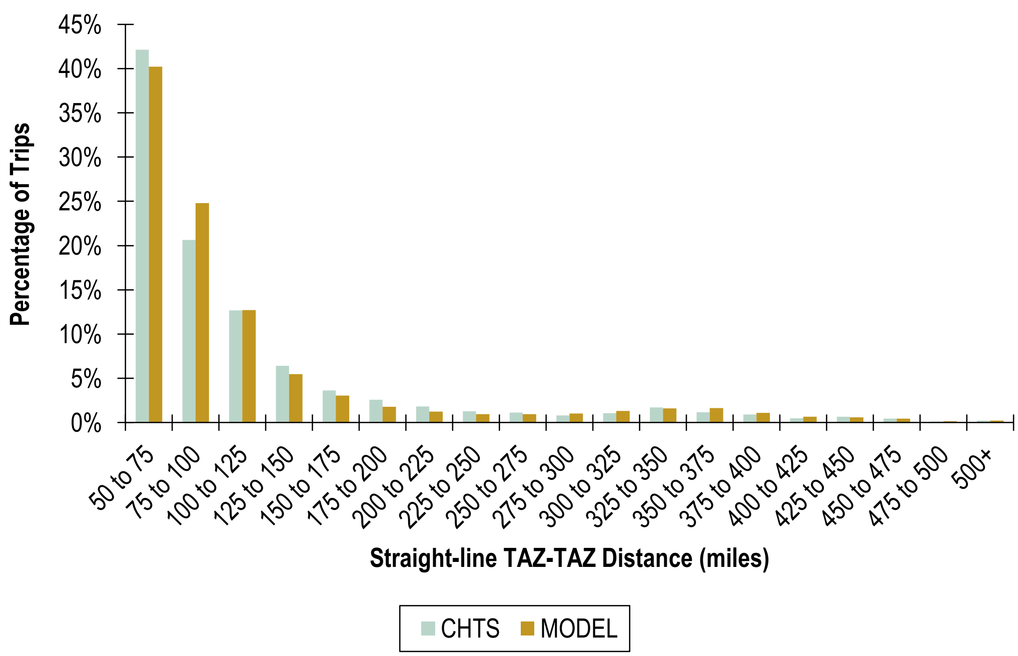


Figure 6.5 Trip Length Frequency Distribution Targets and Calibrated Model – Other Purpose



Region-to-Region Flows

While matching trip length frequencies is important, it was not enough to ensure flows between region pairs were accurate. Region flow targets were developed in two ways. First, overall trip totals by destination region by trip purpose were developed from CHTS data. Second, region-to-region flows by trip purpose also were developed from CHTS data. In order to match the CHTS targets, new constants were added. Table 6.14 shows the calibrated region-to-region flows versus the region-to-region targets.

Table 6.14 Calibrated Region-to-Region Flows for All Modes

	CHTS		Calibrated Model		Difference	
Major Flows	**Daily Long-Distance Trips**	**Percent of Total Long-Distance Trips**	**Daily Long-Distance Trips**	**Percent of Total Long-Distance Trips**	**Trips**	**Percent Difference**
Intra-SCAG	349,900	23%	359,700	24%	9,800	3%
Intra-MTC	71,300	5%	76,600	5%	5,300	7%
Intra-SJV	55,700	4%	51,300	3%	-4,400	-8%
Intra-SACOG	9,400	1%	6,900	0%	-2,500	-27%
Intra-SANDAG	2,800	0%	1,700	0%	-1,100	-40%
Intra-Other	38,600	3%	48,100	3%	9,500	25%
SCAG to SANDAG	259,700	17%	260,900	17%	1,200	0%
SCAG to SJV	85,700	6%	85,300	6%	-400	-1%
SCAG to MTC	45,600	3%	47,400	3%	1,800	4%
SCAG to SACOG	11,800	1%	14,100	1%	2,300	20%
SCAG to Other	80,500	5%	76,900	5%	-3,600	-4%
MTC to SANDAG	10,000	1%	7,100	0%	-2,900	-29%
MTC to SJV	80,000	5%	96,700	6%	16,700	21%
MTC to SACOG	116,500	8%	112,500	7%	-4,000	-3%
MTC to Other	136,800	9%	117,700	8%	-19,100	-14%
SJV to SANDAG	7,800	1%	7,100	0%	-700	-9%
SJV to SACOG	25,500	2%	27,400	2%	1,900	7%
SJV to Other	60,200	4%	61,400	4%	1,200	2%
SACOG to SANDAG	2,500	0%	1,800	0%	-700	-27%
SACOG to Other	43,500	3%	36,400	2%	-7,100	-16%
SANDAG to Other	9,100	1%	6,100	0%	-3,000	-33%
Total	**1,502,900**	**–**	**1,503,100**	**–**	**200**	**–**

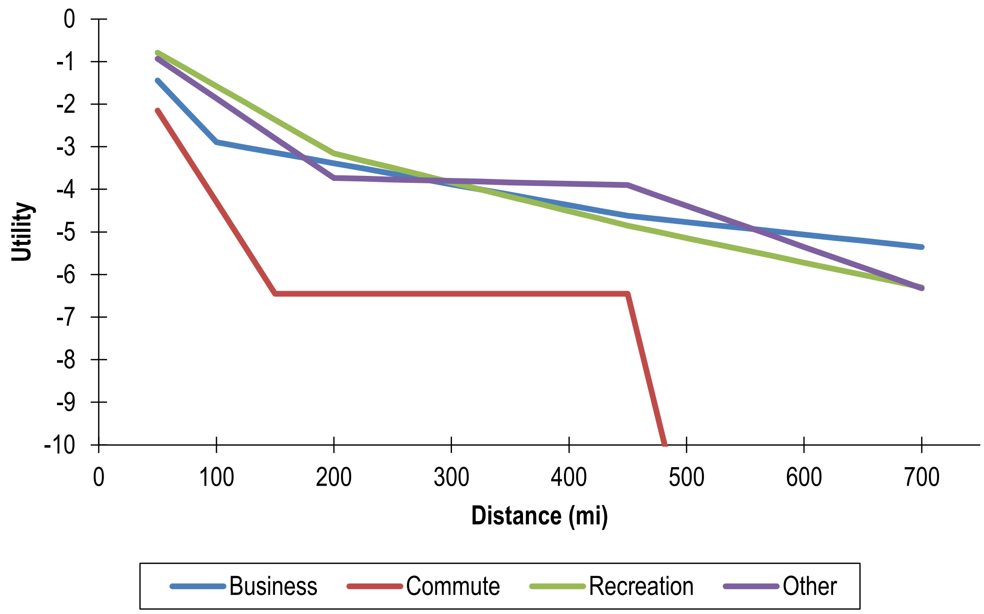
Destination Choice Calibrated Coefficients

Calibration was performed on the piecewise linear distance coefficients described above. Table 6.15 shows the estimated and final calibrated distance coefficients by trip purpose for the destination choice models. To better illustrate their effect on the utility function, Figure 6.6 plots the effect distance has on the utility function in the calibrated model for each trip purpose. The high-income segment is illustrated in Figure 6.6, since this segment has the flattest distance curves among income groups.

Table 6.15 Estimated and Calibrated Distance Coefficients by Trip Purpose

Distance Coefficients	Estimated	Calibrated
Business Purpose		
Distance – All	-0.0319	-0.0310
Max (0, Distance – 100)	0.0285	0.0244
Max (0, Distance – 450)	-0.0097	0.0020
Commute Purpose		
Distance – All	-0.0403	-0.0460
Max (0, Distance – 150)	0.0367	0.0430
Max (0, Distance – 450)	-0.0143	-0.1130
Recreation Purpose		
Distance – All	-0.0129	-0.0158
Max (0, Distance – 200)	0.0084	0.0092
Max (0, Distance – 450)	-0.0057	0.0011
Other Purpose		
Distance – All	-0.0157	-0.0200
Max (0, Distance – 200)	0.0129	0.0178
Max (0, Distance – 450)	-0.0103	-0.0094

Figure 6.6 Impact of Distance on Destination Choice Utility Function by Trip Purpose – High-Income Traveler Segment



In addition to the distance coefficients, the models include two sets of constants that were not part of the estimated models, but were added to better fit observed data during the calibration process. The first set of constants relates to the destination super-region, taking a value of 1 if the TAZ is a member of the destination super-region. Six super-regions were identified: SACOG, MTC, SCAG, SANDAG, the San Joaquin Valley, and the rest of the State. Table 6.16 presents the final calibrated super-region constants by trip purpose.

Table 6.16 Calibrated Destination Zone Super-Region Constants by Trip Purpose

Super-Region of Destination Zone	Trip Purpose			
	Business	Commute	Recreation	Other
SACOG	-0.229	-0.185	-0.372	-0.056
MTC	-0.669	-0.556	-0.551	-0.289
SCAG	-0.816	-0.933	-0.760	-0.593
SANDAG	-0.914	-0.558	-0.484	-0.532
San Joaquin Valley	-0.071	-0.425	-0.937	-0.318

The second set of constants was introduced because it was found that the model produced too few intraregional trips, as described earlier. These constants use the same super-region definitions above. Since intraregional trips in MTC and SCAG were considered to be most critical, individual calibration constants were used for those super-regions. Each of the other four super-regions has distinct constants as well, but the value of the constants for those super-regions was constrained to equal one another. Part of the reason for this was the sparseness of observed intraregional trip data across those four super-regions. Table 6.17 shows the final calibrated constants by trip purpose.

Table 6.17 Calibrated Constants for Trips with Both Trip Ends within a Single Super-Region

	Trip Purpose			
Super-Region	Business	Commute	Recreation	Other
SACOG	1.137	0.919	0.606	0.591
MTC	0.667	0.503	0.566	0.398
SCAG	0.314	0.222	0.162	0.185
SANDAG	1.137	0.919	0.606	0.591
San Joaquin Valley	1.137	0.919	0.606	0.591
Other	1.137	0.919	0.606	0.591

6.5 Trip Frequency Model Calibration

This section details the calibration process for the trip frequency model. There are four trip-frequency models – one for each trip purpose. The trip frequency models are multinomial logit models of daily person long-distance trips. Each trip frequency model has three choice alternatives: 1) no travel, 2) one long-distance trip traveling alone, and 3) one long-distance trip traveling in a group.

Model Calibration Results

Statewide- and region-specific constants were adjusted within the trip frequency models to match origin region CHTS trip totals. Constants were calibrated to minimize the percent differences between the estimated total trips from the CHTS and the modeled total trips originating from each region. In addition, constants representing alone and group travel also were adjusted to meet targets developed from the CHTS. Table 6.18 and Table 6.19 present the CHTS target trip totals and final calibrated model trips by region and by trip purpose.

Table 6.18 Trip Frequency Calibrated Model Results by Region – Business and Commute Trip Purposes

	Business			Commute		
Region Name	CHTS Trips	Model Trips	Percent Difference	CHTS Trips	Model Trips	Percent Difference
SACOG	7,369	7,407	1%	11,240	11,242	0%
SANDAG	9,948	9,997	0%	25,361	25,366	0%
MTC	29,460	29,591	0%	49,886	49,894	0%
SCAG	63,489	63,698	0%	96,218	96,234	0%
San Joaquin Valley	22,120	22,179	0%	32,962	32,968	0%
Other	15,112	15,191	1%	18,407	18,412	0%
Total	**147,500**	**148,062**	**0%**	**234,074**	**234,115**	**0%**

Table 6.19 Trip Frequency Calibrated Model Results by Region – Recreation and Other Trip Purposes

	Recreation			Other		
Region Name	CHTS Trips	Model Trips	Percent Difference	CHTS Trips	Model Trips	Percent Difference
SACOG	32,343	32,337	0%	34,347	34,339	0%
SANDAG	40,788	40,782	0%	44,297	44,285	0%
MTC	107,889	107,870	0%	108,931	108,900	0%
SCAG	220,361	220,286	0%	261,724	261,677	0%
San Joaquin Valley	71,048	70,996	0%	101,500	101,466	0%
Other	31,017	31,015	0%	67,051	67,023	0%
Total	**503,446**	**503,286**	**0%**	**617,851**	**617,690**	**0%**

Table 6.20 shows trip frequency calibration results by party size for each trip purpose. The CHTS and modeled percentages represent the share by purpose of alone trips versus group trips. As indicated by the table, modeled trips are generated at identical party size splits as observed CHTS trips.

Table 6.20 Trip Frequency Calibrated Model Results by Party Size

Group Size	CHTS	Model
Business		
Alone	61%	61%
Group	39%	39%
Commute		
Alone	76%	76%
Group	24%	24%
Recreation		
Alone	18%	18%
Group	82%	82%
Other		
Alone	25%	25%
Group	75%	75%

Trip Frequency Coefficient Calibration

Two calibration processes were used for trip frequency models. The first involved calibrating trips generated by region of origin. The second involved calibrating trips generated by whether those trips occurred as travel alone or group travel. The estimated trip frequency models did not include constants related to origin region of the trip. These constants were added to the models during the calibration process. Table 6.21 shows the estimated and final calibrated model coefficients for the trip frequency models by trip purpose.

Table 6.21 Impact of Calibration on Trip Frequency Model Coefficients

	Business		Commute		Recreation		Other	
	Initial	Calibrated	Initial	Calibrated	Initial	Calibrated	Initial	Calibrated
Travel Alone Constant – 1 Trip	-12.094	-11.441	-11.479	-10.671	-9.924	-8.81	-6.205	-5.252
Group Travel Constant – 1 Trip	-12.689	-12.594	-12.724	-12.162	-9.744	-9.751	-6.896	-6.522
SACOG – Alone or Group Travel		-0.393		-0.504		0.107		-0.433
MTC – Alone or Group Travel		0.039		0.082		0.264		-0.169
SCAG – Alone or Group Travel		0.181		0.172		0.183		-0.039
SANDAG – Alone or Group Travel		-0.206		0.455		0.143		-0.403
SJ Valley – Alone or Group Travel		0.101		0.132		0.517		0.167

6.6 CALIBRATION OF HSR CONSTANT

As described in Section 5.1, since there was a substantial amount of RP data from the 2012-2013 statewide survey and the 2005 RP/SP survey, constants for air and CVR could be determined with a reasonable degree of certainty while the auto mode served as the base. In addition, the constants for the existing modes, air and CVR, were calibrated to reproduce observed 2010 travel flow data, as described in Section 6.3. Since HSR does not exist in California today, the values of the HSR alternative-specific constants had to be asserted. Three different approaches were considered: simply averaging the air and CVR constants, scaling the HSR constant to have the same relative position between the calibrated air and CVR constants as shown by the constants derived from the SP data, and an "offset approach." The offset approach described below was selected. This approach was reviewed with the RTAP, and we are confident the methodology is appropriate for this context.

SP Offset Method

The SP offset method used the differences between estimated SP constants for air, CVR, and HSR to determine offsets to be applied to the calibrated constants for air or CVR in order to assert HSR constants for model application. Since HSR has some basic similarities to CVR, we asserted that the HSR constant produced by either the air offset or the CVR offset should never be more negative than the CVR constant.

This method produced different results depending on whether the calibrated CVR constant or air constant was used as the basis for the offset. To address this issue, we computed the asserted HSR constants as averages of the results of the SP offsets based on the CVR and air constants.

Accounting for Mode-Specific Wait and Terminal Times in the Constants

The calibrated constants for model application include the disutilities resulting from mode-specific wait and terminal times bundled into the constants. This approach was used since those components of disutility vary by mode rather than by alternative, route, line, or station. The impacts of the wait and terminal times also were bundled into the constants estimated using FIML procedures rather than being explicitly included as separate components in the utility specifications. Table 6.22 shows the implicit disutilities of the mode-specific wait and terminal times included in the calibrated air and CVR constants. Table 6.22 also shows the implied contribution of the wait and terminal times for the HSR constants.

Table 6.22 Contributions of Mode-Specific Wait and Terminal Times to Constants

Modes Compared	Business	Commute	Recreation/Other
Air Constants			
Wait time (minutes)[a]	55	55	55
Terminal time (minutes)[a]	22	22	20
Coefficient of out-of-vehicle time	-0.02534	-0.02534	-0.01359
Contribution of wait time to constant[b]	-1.39	-1.39	-0.75
Contribution of terminal time to constant[b]	-0.56	-0.56	-0.27
High-Speed Rail Constants			
Wait time (minutes)[c]	15	15	15
Terminal time (minutes)[c]	10	10	10
Coefficient of out-of-vehicle time	-0.02534	-0.02534	-0.01359
Contribution of wait time to constant[b]	-0.38	-0.38	-0.2
Contribution of terminal time to constant[b]	-0.25	-0.25	-0.14
Conventional Rail Constants			
Wait time (minutes)[a]	15	15	15
Terminal time (minutes)[a]	3	3	3
Coefficient of out-of-vehicle time	-0.02534	-0.02534	-0.01359
Contribution of wait time to constant[b]	-0.38	-0.38	-0.2
Contribution of terminal time to constant[b]	-0.08	-0.08	-0.04

[a] Air and conventional rail average wait times (from arrival at gate or platform to closing of cabin door or departure of the train) and terminal times (time from entering the airport to arrival at the gate or time from the curb to the train platform) were determined from the 2005 RP/SP survey.

[b] Wait and terminal times have been assumed to be "out-of-vehicle" travel time. In the joint main mode choice – access/egress mode choice model estimation, out-of-vehicle time was modeled as 2.5 times the in-vehicle time for the business and commute trip purposes, and 2.0 times the in-vehicle time for the recreation/other trip purposes.

[c] Average wait time for HSR was asserted to be the same as for conventional rail; terminal times were asserted to be five minutes greater than those for conventional rail to account for larger station sizes.

Development of Base RP and SP Constants for Asserting HSR Constants

RP and SP constants without the contributions of wait and terminal times were used to assert the HSR constants. Table 6.23 summarizes the development of the "unbundled" RP and SP constants. Section A of Table 6.23 shows the constants that were calibrated to reproduce observed mode shares for auto, air, and CVR when the main mode choice model was applied using 2010 input data. The constants estimated from the SP data included in the main mode/access-egress joint model estimation process also are shown in Section A.

Table 6.23 Summary of RP and SP CVR, Air, and HSR Constants

Table Section	Mode	Calibrated Constants[a] (with Bundled Terminal and Wait Times) Business	Commute	Recreation/ Other	Estimated SP Constants[b] (with Bundled Terminal and Wait Times) Business	Commute	Recreation/ Other
A	Air	-8.161	-14.388	-3.856	-4.396	-6.063	0.581
	HSR	–	–	–	1.993	1.163	3.280
	CVR	-6.483	-8.478	-3.746	-0.842	-1.347	2.241
B	SP Scale Coefficient	–	–	–	.478	.478	.642
					Scaled SP Constants[b] (with Bundled Terminal and Wait Times)		
C	Air	–	–	–	-2.101	-2.898	0.373
	HSR	–	–	–	0.953	0.556	2.106
	CVR	–	–	–	-0.402	-0.644	1.439
		Contribution of Wait and Terminal Times			Scaled Contribution of Wait and Terminal Times		
D	Air	-1.951	-1.951	-1.019	-0.933	-0.933	-0.654
	HSR	-0.634	-0.634	-0.340	-0.303	-0.303	-0.218
	CVR	-0.456	-0.456	-0.245	-0.218	-0.218	-0.157
		Net Calibrated Constants[a] (without Terminal and Wait Times)			Scaled SP Constants[b] (without Terminal and Wait Times)		
E	Air	-6.210	-12.437	-2.836	-1.168	-1.965	1.027
	HSR	–	–	–	1.256	0.859	2.324
	CVR	-6.027	-8.021	-3.502	0.184	-0.426	1.596

[a] Constants shown have been calibrated to reproduce observed main mode share targets estimated using CSHTS Data.

[b] Estimated SP Constants and the SP Scale Coefficients are based on the maximum likelihood estimation of the joint main mode/access-egress mode choice model.

Section B of the table shows the SP scale factors estimated from the SP data included in the main mode/access-egress joint model estimation process. In the joint RP/SP mode choice model estimation, the utility functions for SP choices included a scale value that, like the model coefficients, was estimated using FIML procedures. The scale on SP response utility functions accounted for the fact that the RP and SP choice exercises were systematically different and, thus, should not be assumed to have the same size residual errors. Since the terminal and wait times were implicitly included in the estimated SP coefficients, we needed to scale the SP constants and the contributions of the wait times and terminal times by the estimated SP scale factors prior to determining the offsets to the calibrated constants.

Section C of the table shows the scaled SP constants. The values in Section C are simply the Estimated SP Constants shown in Section A multiplied by the Scale Factors shown in Section B.

Section D of the table shows the contributions of the wait and terminal times included in the calibrated constants shown in Section A of the table or Section C of the table for the Estimated SP Constants. The contributions of the wait and terminal times for the various modes are based on the information summarized in Table 6.22.

Section E of the table shows the net constants without the contributions of the wait and terminal times.

Calibrated HSR Constants

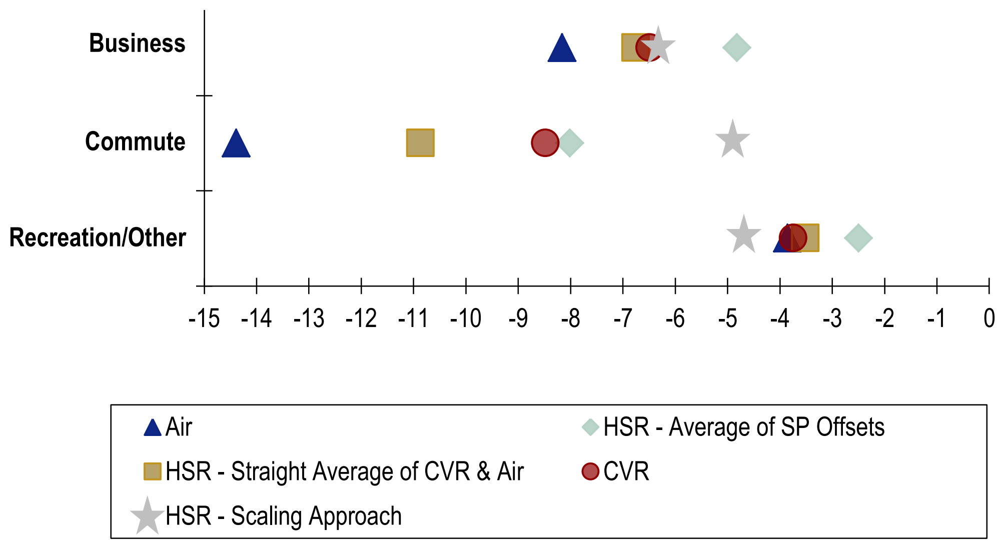
Table 6.24 summarizes the calibrated CVR and air constants as well as the asserted HSR constants based on the three different procedures. Figure 6.7 shows the relative values of the unbundled constants in relation to auto (the base, zero, "constant").

Table 6.24 Summary of CVR, Air, and HSR Constants

	Net Constants (without Bundled Terminal and Wait)			Equivalent Minutes of Net Constants (without Bundled Terminal and Wait)		
Mode	**Business**	**Commute**	**Recreation/ Other**	**Business**	**Commute**	**Recreation/ Other**
Air	-6.21	-12.44	-2.84	613	1,227	417
HSR						
Straight Average of CVR and Air	-6.12	-10.23	-3.17	604	1,009	466
Scaling Approach	-5.76	-4.34	-4.35	568	428	641
Average of SP Offsets	-4.19	-7.38	-2.16	413	728	317
CVR	-6.03	-8.02	-3.50	595	791	515
	Constants (with Bundled Terminal and Wait)			**Equivalent Minutes of In-Vehicle Time (with Bundled Terminal and Wait)**		
Air	-8.16	-14.39	-3.86	805	1,419	567
HSR						
Straight Average of CVR and Air	-6.75	-10.86	-3.51	666	1,072	516
Scaling Approach	-6.39	-4.97	-4.69	631	490	691
Average of SP Offsets	-4.82	-8.01	-2.50	475	790	367
CVR	-6.48	-8.48	-3.75	640	836	551

Note: Shaded rows are recommended net (unbundled) and bundled constants.

Figure 6.7 Unbundled Mode Values of CVR, Air, and HSR Constants in Comparison to Auto



The following observations can be made regarding the results for the unbundled constants:

- There was substantial variation in the asserted HSR constants using the three different methods.
- The SP offset method produced HSR constants that were less negative than the air constants in all cases. The implication was that, all else being equal, travelers who responded to the 2005 RP/SP survey preferred the use of HSR over air.
- In contrast, for recreation/other, the scaling method produced an HSR constant that was more negative than the air constant, suggesting that travelers who responded to the 2005 RP/SP survey preferred the use of air over HSR for recreation/other travel.
- The SP offset method was designed to produce an HSR constant less negative than the CVR constant. Since a comparable constraint was not included in the scaling method, the recreation/other HSR constant was more negative than the CVR constant. Logically, the HSR constant would be constrained to be the same as the CVR constant in this case.

Note that when the impacts of the wait and terminal times were added back into the constants, the relative positions of air and CVR constants for recreation/other travel reversed due to the differences in the wait and terminal times for those two modes (see Table 6.24).

7.0 Intraregional Model Development and Calibration

7.1 Overview

Short-distance trips (less than 50 miles in length) that take place within the SCAG or MTC region are modeled with separate intraregional mode choice models. Both the SCAG and MTC intraregional mode choice models are based on a refined version of the MTC BAYCAST model. The models use static trip tables adopted from the SCAG and MTC regional models.[16] In addition, the models use transportation LOS characteristics and household characteristics developed specifically for the HSR model system. This section begins by discussing the mode choice model structure. Next, the inputs that were developed for the SCAG and MTC mode choice models, including development of the skims, socioeconomic data, and trip tables, are reported. Finally, we provide the process and results of model calibration for both SCAG and MTC. During application, the models are run for all trips (both less than and greater than 50 miles in length), and then the long-distance trips (greater than or equal to 50 miles in length) are removed from the results. Thus, the model results presented in this section encompass all trip lengths.

7.2 Mode Choice Model Structure

Overview

The SCAG and MTC intraregional mode choice models use a nested logit model structure, as shown in Figure 7.1, which is based on the MTC Baycast model. The models are stratified by trip purpose and market segmentation:

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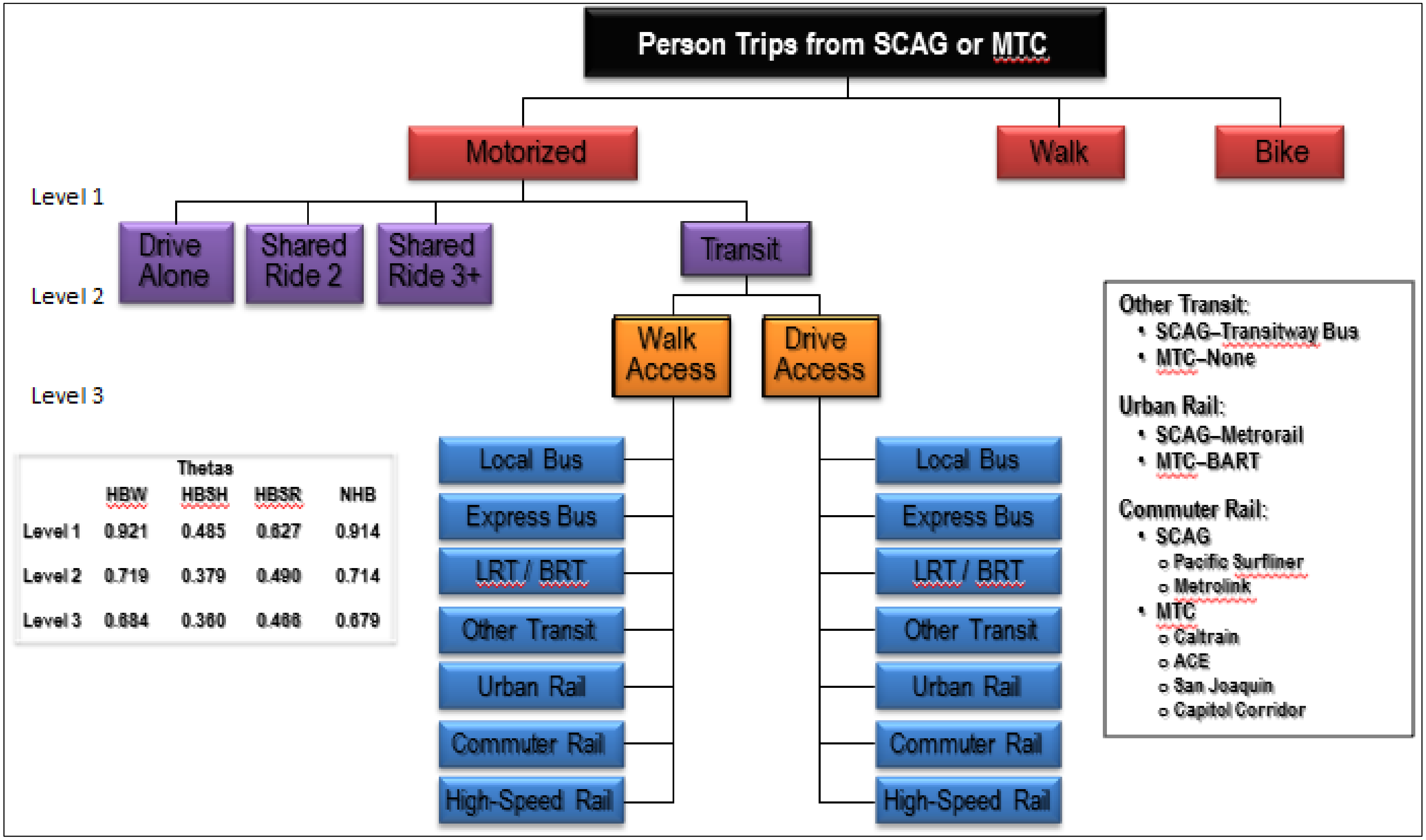
[16] Southern California Association of Governments, *SCAG Regional Travel Demand Model and 2008 Model Validation*, June 2012; and Metropolitan Transportation Commission, *Travel Model Development: Calibration and Validation*, May 2012.

Figure 7.1 Mode Choice Model Structure



- Home-based work:
  - Zero auto households;
  - Auto < workers households;
  - Auto > worker, low-income households;
  - Auto > worker, medium-income households; and
  - Auto > worker, high-income households.
- Home-based shop.
- Home-based recreation/other.
- Nonhome-based work.
- Nonhome-based other.

The mode choice model considers the following modes:

- **Auto Modes:**
  - Drive alone,
  - Shared ride 2, and
  - Shared ride 3.
- **Nonmotorized Modes:**
  - Walk, and
  - Bike.
- **Transit Modes:**
  - Local bus;
  - Express bus;
  - Light rail, BRT, and ferry;
  - Other transit (i.e., Transitway Bus for SCAG, none for MTC);
  - Urban rail (e.g., BART, Metrorail);
  - Commuter rail (e.g., Caltrain, ACE, Metrolink, Pacific Surfliner); and
  - HRS.

Value-of-Time Adjustment

In order to account for the new market segmentations, the cost coefficients were adjusted so that the value-of-time for each income group was 37 percent of the average wage rate. The 37 percent average wage rate value comes from an average of the MTC (34 percent) and SCAG (41 percent) percentage of average wage rate found using the original coefficients and average regional income.

Table 7.1 shows the average wage rate for each market segmentation in the Intra-SCAG mode choice model.

Table 7.1 Average Wage Rate for Each Market Segmentation in Intra-SCAG Mode Choice Model

SCAG Model Breakpoints (1999 Dollars)	SCAG Model Breakpoints (2005 Dollars)	Average Income (2005 Dollars)	Average Wage Rate (2005 Dollars)	Implied VOT from Adjusted Coefficients (2005 Dollars)
0 Vehicle HH	0 Vehicle HH	$30,067	$14.46	$5.38
Worker > Veh	Worker > Veh	$68,842	$33.10	$12.33
Less than $25K	Less than $30K	$15,961	$7.67	$2.86
$25K to $50K	$30K to $60K	$44,310	$21.30	$7.93
Greater than $50K	Greater than $60K	$134,868	$64.84	$24.15

Model Coefficients

The model coefficients and structure for the home-based work, home-based shop/other, home-based social/recreation, and nonhomed Intraregional Mode Choice models are shown in Table 7.2 though Table 7.5, respectively.

Table 7.2 Home-Based Work Intraregional Mode Choice Model

Included In Utility								CAHSRA Intraregional Models (All Dollar-Related Information in 2005 Dollars)				
Drive Alone	Shared Ride 2	Shared Ride 3+	Drive to Transit	Walk to Transit	Bike	Walk	Variable	0 Auto Hholds	Wrkrs < Autos	$0K to $25K	$25K to $50K	$50K or more
					✓		Constant	See Calibration Section				
					✓		LnEmpDi	0.3522	0.3522	0.3522	0.3522	0.3522
			✓	✓			LnEmpDj	0.3929	0.3929	0.3929	0.3929	0.3929
						✓	LnEmpDj	0.154	0.154	0.154	0.154	0.154
✓							Veh/HH	0.8805	0.8805	0.8805	0.8805	0.8805
	✓						Veh/HH	0.6491	0.6491	0.6491	0.6491	0.6491
		✓					Veh/HH	0.6731	0.6731	0.6731	0.6731	0.6731
			✓				Veh/HH	0.4098	0.4098	0.4098	0.4098	0.4098
	✓						Single VHH	0.6021	0.6021	0.6021	0.6021	0.6021
				✓			No VHH	0.3957	0.3957	0.3957	0.3957	0.3957
✓							Wrkr/HH	-0.1765	-0.1765	-0.1765	-0.1765	-0.1765
	✓						Multi-Wrkr/HH	-0.6688	-0.6688	-0.6688	-0.6688	-0.6688
✓							Pers/HH	-0.2229	-0.2229	-0.2229	-0.2229	-0.2229
✓							IncomeLeg1	0.0000280	0.0000280	0.0000280	0.0000280	0.0000280
	✓	✓					IncomeLeg1	0.0000241	0.0000241	0.0000241	0.0000241	0.0000241
✓	✓	✓					IVTT	} -0.02393	} -0.02393	} -0.02393	} -0.02393	} -0.02393
			✓	✓			IVTT					
					✓		IVTT	-0.03612	-0.03612	-0.03612	-0.03612	-0.03612
			✓	✓			Wait	-0.03765	-0.03765	-0.03765	-0.03765	-0.03765
✓	✓	✓					Walk (PTT + ATTj)	} -0.06694	} -0.06694	} -0.06694	} -0.06694	} -0.06694
			✓	✓			Walk					
						✓	LnWalkTime	-2.321	-2.321	-2.321	-2.321	-2.321
✓	✓	✓					Cost	} -0.00266722	} -0.0011649	} -0.00502444	} -0.00180985	} -0.00059462
			✓	✓			Cost					
					✓		Stanfordj	2.27	2.27	2.27	2.27	2.27
					✓		PaloAltoj	1.72	1.72	1.72	1.72	1.72
					✓		Berkeleyj	1.097	1.097	1.097	1.097	1.097
✓							Corej	-0.781	-0.781	-0.781	-0.781	-0.781
			✓				Corej	0.825	0.825	0.825	0.825	0.825
✓	✓	✓	✓	✓			Motorized Theta	0.9208	0.9208	0.9208	0.9208	0.9208
(✓)	(✓)	(✓)	✓	✓			Transit Theta	0.7194	0.7194	0.7194	0.7194	0.7194
							Submode Theta	0.6835	0.6835	0.6835	0.6835	0.6835

Table 7.3 Home-Based Shop/Other Intraregional Mode Choice Model

Included In Utility								
Drive Alone	**Shared Ride 2**	**Shared Ride 3+**	**Drive to Transit**	**Walk to Transit**	**Bike**	**Walk**	**Variable**	**CAHSRA Generic Intraregional Models (All Dollar-Related Information in 2005 Dollars)**
							Constant	See Calibration Section
	✓						LnPHH	0.6635
		✓					LnPHH	2.236
			✓	✓			Veh/HH	-0.3352
✓							LnIncome	0.1753
	✓						LnIncome	0.1004
✓	✓	✓	✓	✓			Time (Total)	-0.05815
					✓	✓	Time (Total)	-0.11997
✓	✓	✓	✓	✓			LnCost	-0.2037
			✓	✓			Corej	2.375
✓	✓	✓					LnAreaDeni	-0.4701
					✓		Stanfordj	5.133
					✓		Berkeleyj	3.363
					✓		PaloAltoj	2.841
✓							Zero WHH	-0.2273
			✓	✓			Zero VHH	3.291
						✓	Zero VHH	3.5795
✓	✓	✓	✓	✓			Motorized Theta	0.4847
							Transit Access Theta	-0.03612
							Submode Theta	-0.03765

Table 7.4 Home-Based Social/Recreational Intraregional Mode Choice Model

Included In Utility								
Drive Alone	**Shared Ride 2**	**Shared Ride 3+**	**Drive to Transit**	**Walk to Transit**	**Bike**	**Walk**	**Variable**	**CAHSRA Generic Intraregional Models (All Dollar-Related Information in 2005 Dollars)**
							Constant	See Calibration Section
		✓					LnPHH	1.834
			✓	✓			Veh/HH	-0.7475
	✓						LnIncome	0.2070
					✓		Income	-0.0094
✓							IVTT	-0.02745
	✓	✓	✓	✓			IVTT	-0.02745
					✓		IVTT	-0.04377
✓							OVTT	-0.06806
	✓	✓	✓	✓			OVTT	-0.06806
						✓	OVTT	-0.10853
✓							LnCost	-1.0516
	✓	✓	✓	✓			LnCost	-1.0516
			✓	✓			Corej	0.9694
			✓	✓			LnAreaDeni	0.3217
					✓		Stanfordj	3.5226
(✓)	✓	✓	✓	✓			Motorized Theta	0.6271
							Transit Access Theta	0.4899
							Submode Theta	-0.03612

Table 7.5 Nonhome-Based Work and Nonhome-Based Other Intraregional Mode Choice Model

Included In Utility							
Auto Driver	**Auto Passenger**	**Drive to Transit**	**Walk to Transit**	**Bike**	**Walk**	**Variable**	**CAHSRA Generic Intraregional Models (All Dollar-Related Information in 2005 Dollars)**
✓						Constant	See Calibration Section
✓						AreaDeni	-0.0005277
					✓	AreaDeni	0.0004566
✓	✓	✓	✓			IVTT	-0.03232
				✓		IVTT	-0.03535
		✓	✓			Wait	-0.07836
✓	✓	✓	✓			Walk	-0.07583
					✓	Walk	-0.08293
✓	✓	✓	✓			LnCost	-0.8939
		✓	✓			Motorized Theta	0.9144
						Transit Access Theta	0.7144
						Submode Theta	0.6787

7.3 INPUTS TO MODE CHOICE MODEL

Transit Skims

Transit skims for the SCAG and MTC models are developed by importing the transit skimming input files from each respective regional model system. The SCAG transit skimming process is performed using Cube, but the SCAG Regional Model is in TransCAD. Input files, such as highway network, park-and-ride stations, transit routes, transit run time, and transit fare, were converted from TransCAD into Cube format for the use in the SCAG intraregional skimming process.

The MTC Regional Model uses the Cube transportation modeling software and has an identical zonal structure to the CAHSR MTC intraregional model. Therefore, it was straightforward to transfer the skim input files from the regional model to the CAHSR MTC intraregional model.

Both models have separate skims for each of three trip purpose combinations:

1. Home-based work.
2. Home-based shopping.
3. Home-based social/recreation and nonhome-based and transit mode: local bus; express bus; light rail, BRT, and ferry; other transit (i.e., Transitway Bus for SCAG, none for MTC); urban rail (e.g., BART, Metrorail); commuter rail (e.g., Caltrain, ACE, Metrolink, Pacific Surfliner); and HSR.

This results in a total of 21 separate skims for the SCAG region and 18 separate skims for the MTC region.

The transit skimming process extracts the LOS matrices of total trip costs and their components into a zone-to-zone matrix. Transit route evaluation identifies a single best path (BESTPATHONLY=TRUE) between each origin-destination (OD) pair. In addition, the "MustUseMode" factor is used to ensure that a desired mode is included on the best path for a specific skim. The transit skims use path-building weights consistent with mode choice, as shown in Table 7.6.

Table 7.6 Final Path-Building Weights in SCAG Skims

	HBW	HBSH+O	HBSR, NHB
In-vehicle time	1	1	1
Walk time	2.8	1	2.4
Wait time	1.6	1	2.4
Transfer penalty	5	5	5
Transfer factor	1	1	1
Boarding penalty	0	0	0

Auto and Nonmotorized Skims

Auto skims for SCAG intraregional model were imported from SCAG's Regional Model for year 2008. These skims were used in the intraregional mode choice models. Walk and bike travel times were calculated using the distances from the auto skims. A speed of 3 mph was assumed for walking and 12 mph for bicycling.

Auto skims and walk and bike skims for the MTC intraregional model were imported from the MTC Regional Model for year 2010. These skims were used as is in the intraregional mode choice models. Travel times for bicycling and walking were obtained by converting walk and bike distances from the MTC skims into time. A speed of 3 mph was assumed for walking and 12 mph for bicycling.

Socioeconomic Datasets

The formats of the socioeconomic dataset for both the SCAG and MTC intraregional model are identical and are based on required inputs for the MTC Baycast Mode Choice Model, as shown in Table 7.7. SCAG's Regional Model socioeconomic dataset for year 2008 and MTC's Regional Model socioeconomic dataset for year 2010 were converted into this format to create the intraregional model socioeconomic dataset for each region.

Table 7.7 Intraregional Socioeconomic Dataset Variables

Column Number	Column Header	Description
1	TAZ	Intraregional TAZ
2	MHHINC	Median HH income
3	TOTHH	Total Households
4	TOTPOP	Total Population
5	EMPRES	Number of Employed Residents
6	AUTOS	Total Number of HH autos
7-21		Decimal Percent of Workers (0, 1, 1+) in HHs by Market Segmentation (0 Auto HHs, Worker > Auto HH, Auto Sufficient Low-Income HHs, Auto Sufficient Middle Income HHs, Auto Sufficient High-Income HHs)
22-36		Decimal Percent of Vehicles (0, 1, 1+) in HHs by Market Segmentation (0 Auto HHs, Worker > Auto HH, Auto Sufficient Low-Income HHs, Auto Sufficient Middle Income HHs, Auto Sufficient High-Income HHs)
37-39		Decimal Percent of Workers (0, 1, 1+) in all HHs
40-42		Decimal Percent of Vehicles (0, 1, 1+) in all HHs
43-47		Total HHs in each Market Segmentation (0 Auto HHs, Worker > Auto HH, Auto Sufficient Low-Income HHs, Auto Sufficient Middle Income HHs, Auto Sufficient High-Income HHs)
48	VHH	Average Vehicles per HH
52	TEMP	Total Employment
53	TACRES	Total Acreage
54	DLPKG	Daily Parking Cost (year 2005 cents)
55	HRPKG	Hourly Parking Cost (year 2005 cents)
56	AREATYPE	Area Type

Trip Tables

Since the SCAG Regional Model is a traditional trip-based model and the MTC Regional Model is an activity-based model, different methodologies were used to develop the trip tables for each respective intraregional model.

SCAG Trip Table Development

The SCAG regional model includes trip tables for the following trip purposes:

- Home-based work (HBW),
- Home-based shopping (HBSH),
- Home-based social/recreational (HBSR),
- Home-based other (HBO),
- Nonhome-based work (NHBW), and
- Nonhome-based non-work (NHBNW).

These trip tables are available for peak and off-peak periods. In addition, the SCAG Regional Model also includes home-based school (HBSC) trips and home-based serve passenger (HBSP) trips, but they are assumed to not use HSR and are not included in the mode choice model. Each of the home-based trip tables is segmented by household type:

- Zero-vehicle households;
- Auto deficient households (workers > vehicles, vehicles > 0);
- Auto sufficient households, low income (less than $25,000);
- Auto sufficient households, medium income ($25,000 to $50,000); and
- Auto sufficient households, high income (more than $50,000).

The above trip purposes and household segmentations are retained for the SCAG intraregional model. Therefore, the year 2008 SCAG Regional Model Trip Tables were used directly in the SCAG Intraregional Model without further processing.

MTC Trip Table Development

The year 2010 trip tables were developed from the MTC activity-based model (ABM) trip roster data[17]. The total number of households, persons, and trips is shown in Table 7.8. Individual trips from the roster data were used "as is." Joint trips were converted from the joint trip data by enumerating one trip per

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[17] Trip roster data from an ABM mimics household and person travel data from a household travel survey. The roster information can easily be processed to create trip matrices.

participant for each joint trip. For example, one joint trip with three participants generates three individual trips in the conversion process.

Table 7.8 Total Households, Persons, and Trips in MTC Trip Roster Data for Year 2010

		Trips		
Households	Persons	Individual	Joint	Total
2,732,722	7,053,334	22,872,096	1,424,946	24,297,042

Market segments were identified as shown in Table 7.9. This segmentation is identical to the SCAG intraregional model, and distinguishes among households based on vehicle ownership, auto deficiency (based on whether the number of workers exceeds the number of autos), and household income level. Income was converted to year 2010 dollars from year 2000 dollars before segmenting the population.

Table 7.10 lists each activity in the MTC trip roster data and shows the corresponding CAHSR intraregional model purpose.

The trip-end activities were used to assign each trip to a specific trip purpose, as shown in Table 7.11. If either end involves escorting, then the trip is considered a Serve Passenger trip. Otherwise, if one trip end is at home, then the purpose is Home-Based; if neither end is at home, then the trip is nonhome-based.

Table 7.9 Total Households by Intraregional Market Segmentation for Year 2010

Market Segmentation	Households	Percent Households
All households with zero autos	255,243	9.3%
All households with autos ≥1 and workers > autos	171,776	6.3%
All households with autos ≥1 and autos ≥ workers		
Income (2010) < $25,000	373,956	13.7%
$25,000 ≤ Income (2010) < $50,000	399,630	14.6%
Income (2010) ≥ $50,000	1,532,117	56.1%

Table 7.10 Correspondence between Trip Purposes in MTC ABM Model and Intraregional Model

MTC Model	Intraregional Model
Home	Home
Work	Work
atwork	Work
work	Work
eatout	Shop/Other
othdiscr	Shop/Other
othmaint	Shop/Other
shopping	Shop/Other
social	Social/Recreation
school	School
escort	Serve Passenger
university	University

Table 7.11 Determination of Home-Based versus Non-Home-Based Trip Purposes

One end at Home, the other at…		If neither end is at Home…	
...Work	HB Work	…& one end is at Work	NHBW
...Shop/Other	HB Shop/Other	…& neither end is at Work:	NHBO
...Soc/Rec	HB Soc/Rec		
...School	HB School		
...Univ	HB University		
If either end involves escorting (serve passenger):			
	Serve		

Table 7.12 shows the resulting number of trips by purpose. Table 7.13 shows additional detail on HBW trips by market segment and time of day.

Table 7.12 Total Trips by MTC Intraregional Trip Purpose
For Year 2010

Trip Purpose	Frequency	Percent	Cumulative Percent
Model Purposes			
HBW	4,026,249	16.6	16.6
HBShopOth	8,163,632	33.6	50.2
HBSocRec	825,608	3.4	53.6
NHBW	2,646,460	10.9	64.5
NHBO	2,476,458	10.2	74.7
Nonmodeled Purposes			
HBSchool	1,749,077	7.2	81.9
ServePass	4,005,268	16.5	98.3
HBUniv	404,290	1.7	100.0
Total	**23,892,752**	**100.0**	

Table 7.13 HBW Trips by Market Segment and Time of Day
For Year 2010

Market Segment	Peak	Off-Peak	Total
All households with zero autos	139,105	46,839	185,944
All households with autos ≥1 and workers > autos	446,206	173,267	619,473
All households with autos ≥1 and autos ≥workers	112,526	49,129	161,655
Income (2010) < $25,000	282,755	113,618	396,373
$25,000 ≤ Income (2010) < $50,000	1,939,807	722,997	2,662,804
Total	**2,920,399**	**1,105,850**	**4,026,249**

The raw trip roster data are in OD format. The data were converted into production-attraction format as follows:

- If one of the trip ends was at home, then the home end was considered the production end;
- Otherwise, if one trip end was at work, then the work end was considered the production end; and
- Otherwise, the origin was considered to be the production end.

7.4 MODE CHOICE CALIBRATION

Calibration targets for the intraregional SCAG and MTC models were set to the mode choice output from the year 2008 SCAG and year 2010 MTC Regional Models.

A concern in model calibration is of overfitting the model and making it insensitive to network changes in forecast years. Although there are no formally adopted rules or standards to guide regional mode choice model calibration, informal guidelines have emerged from best practices over the years. The following guidelines were developed for use in this model calibration based on the informal guidelines:

- The absolute value of alternative-specific constants (ASC) should generally not exceed 5.0.
- In-vehicle time is weighted equally across all modes, except in cases where the transit-mode operates on a fixed guideway, has well defined and visible service, and/or station and car amenities.
- Transit mode-specific constants are constrained across market segments.
- Transit access constants are calibrated to represent the difference in utility generically across all transit modes. Transit mode-specific constants across access modes are constrained within each trip purpose and time period (i.e., the transit mode constants are the same within the drive-transit and the walk-transit nests).
- Constants for fixed guideway transit modes (BRT, LRT, URBR, and CVR) are constrained to be greater than or equal to the Local Bus constant.

During calibration, it became clear that changes needed to be made to the input trip tables and target mode shares in order to successfully match the calibration targets and observed transit boarding data. These adjustments are discussed first, followed by details of the calibration process and results.

Adjustments to Trip Table Inputs

The trip tables and target mode shares from the existing regional models for MTC and SCAG were used as starting points for the HSR intraregional models, as described in Section 7.3. Initial calibration work concluded that the numbers of intercounty trips were too low. In the SCAG region, there also were too few intercounty trips to downtown Los Angeles. To resolve these issues, the 2010 weighted CHTS data, described in Section 2.2, were used to factor the input trip table at the county level.

Table 7.14 and Table 7.15 compare the county-level trips across all purposes from the regional model to the 2010 CHTS for SCAG and MTC. Note that downtown Los Angeles, where the area type is urban CBD, is identified as a separate "county." There are substantial differences in the trip rates by county for both regions. In the SCAG region, the model trip rates are consistently higher than the CHTS trip rates, while in the MTC region, the model trip rates are lower than the CHTS rates, except in Napa County. The regional models predict similar aggregate trips rates per capita, but the CHTS trip rates show that the MTC region has a significantly higher trip rate per capita than the SCAG region.

Table 7.14 SCAG Regional Model to CHTS Trip Rate by County Comparison

County	SCAG Regional Model			CHTS Regional Model			Percentage Difference in SCAG vs. CHTS Trips per Capita
	2010 Total Population	Production-Based Trips	Trips per Capita	2010 Total Population	Production-Based Trips	Trips per Capita	
Imperial	170,003	427,602	2.515	174,529	412,318	2.362	6.5%
Los Angeles	9,526,514	32,596,941	3.422	9,573,476	28,098,160	2.935	16.6%
Los Angeles – Downtown	244,737	968,141	3.956	241,155	880,744	3.652	8.3%
Orange	2,995,637	11,297,302	3.771	3,009,932	8,971,303	2.981	26.5%
Riverside	2,128,305	6,623,134	3.112	2,189,710	5,956,955	2.720	14.4%
San Bernardino	2,009,652	6,470,560	3.220	2,035,295	5,086,790	2.499	28.8%
Ventura	813,037	2,836,387	3.489	823,340	2,407,939	2.925	19.3%
Total	**17,887,885**	**61,220,067**	**3.422**	**18,047,437**	**51,814,209**	**2.871**	**19.2%**

Table 7.15 MTC Regional Model to CHTS Trip Rate by County Comparison

County	MTC Regional Model			CHTS Regional Model			Percentage Difference in MTC vs. CHTS Trips per Capita
	2010 Total Population	Production-Based Trips	Trips per Capita	2010 Total Population	Production-Based Trips	Trips per Capita	
Alameda	1,500,589	4,721,664	3.147	1,509,263	5,937,052	3.934	-20.0%
Contra Costa	1,026,444	2,890,908	2.816	1,049,445	3,752,415	3.576	-21.2%
Marin	252,526	778,503	3.083	252,459	985,012	3.902	-21.0%
Napa	136,026	404,308	2.972	136,473	367,704	2.694	10.3%
San Francisco	797,674	3,849,035	4.825	805,208	3,976,590	4.939	-2.3%
San Mateo	707,400	2,583,982	3.653	718,306	2,628,389	3.659	-0.2%
Santa Clara	1,750,925	6,482,318	3.702	1,781,826	6,767,198	3.798	-2.5%
Solano	401,662	1,164,584	2.899	413,611	1,242,115	3.003	-3.5%
Sonoma	480,088	1,421,751	2.961	483,866	1,623,960	3.356	-11.8%
Total	**7,053,334**	**24,297,053**	**3.445**	**7,150,457**	**27,280,435**	**3.815**	**-9.7%**

The CHTS trip rates are expected to be more accurate than the regional model rates at the county level, so intercounty factors have been calculated from the ratio of CHTS data to regional model county-to-county trips. This approach is used to provide a consistency across both regions since their modeling procedures are inherently different and because, as noted above, initial calibration results suggested that the long-distance intercounty trips estimated from the existing regional models were too low.

The factors are constrained to be between 0.25 and 4.00. A factor greater than 1 increases the number of trips, and less than 1 decreases the number of trips. The factor matrices are symmetrical, so only the top one-half is shown in Table 7.16 and Table 7.17. The net effect of the factors is that MTC trips are increased by 12 percent and SCAG trips are decreased by 15 percent relative to the regional model trips.

Table 7.16 SCAG County-to-County Input Trip Table Factors

County-to-County Factors	Imperial	Los Angeles	Los Angeles – Downtown	Orange	Riverside	San Bernardino	Ventura
Imperial	0.87	4.00	0.25	4.00	3.65	4.00	0.25
Los Angeles		0.90	0.72	0.43	0.48	0.62	0.50
Los Angeles – Downtown			1.33	0.42	1.03	1.25	0.87
Orange				0.86	0.53	0.41	0.54
Riverside					0.93	0.50	0.35
San Bernardino						0.83	0.31
Ventura							0.88

Table 7.17 MTC County-to-County Input Trip Table Factors

County-to-County Factors	Alameda	Contra Costa	Marin	Napa	San Francisco	San Mateo	Santa Clara	Solano	Sonoma
Alameda	1.31	0.86	0.72	1.53	0.81	0.51	0.52	1.13	1.66
Contra Costa		1.21	0.80	0.46	0.69	0.97	0.76	0.66	0.92
Marin			1.26	0.52	0.75	0.35	1.20	0.74	1.01
Napa				1.00	0.47	1.25	3.75	0.52	0.62
San Francisco					1.48	0.56	2.59	0.75	0.56
San Mateo						1.19	0.81	2.08	1.14
Santa Clara							1.10	2.67	4.00
Solano								0.94	1.10
Sonoma									1.08

Adjustments to Target Shares

The commuter rail and urban rail regional model mode share results were reviewed against boarding data for validity. The MTC model calibration and validation report[18] showed that the MTC regional model commuter rail modeled boardings to be about 50 percent lower than the observed boardings. The MTC regional model mode choice results were revised to increase the total CVR trips to 36,800, which improved the modeled boardings. The revised CVR trip target was developed from the process, as shown in Table 7.18.

Table 7.18 MTC Revised CVR Target Trips

	Estimated Intraregional Trips (Based on January 2010 Boarding Count Data)
Caltrain	36,800
ACE	1,000
Amtrak	1,200
CVR-CVR transfers (remove double-counting)	-200
Remove School & Serve Passenger Purpose Trips	-2,000
Revised CVR Target Trips	**36,800**

Adjustments to Skimming Process

Transit Path Search

Initial calibration revealed that CVR and Urban Rail (URBR) transit modes have a time-advantage over Local Bus because the ASCs for CVR and URBR are positive relative to Local Bus. However, insufficient paths were found for CVR and URBR because the default path search constraints were too restrictive. The calibrated model and expectations are that the CVR and URBR paths will be preferred to Local Bus, even if the path time is longer, because of increased vehicle and stations amenities, service reliability, and service visibility. The path search constraints (in Cube, these are defined as a "Spread Factor") were increased to increase the number of available paths for CVR and Urban Rail.

Drive-Access Time Weighting

The MTC mode choice model structure weights the drive-access time equal to in-vehicle time. While this is not an unreasonable assumption on its own, skimming with equal drive-access and in-vehicle time weights can lead to

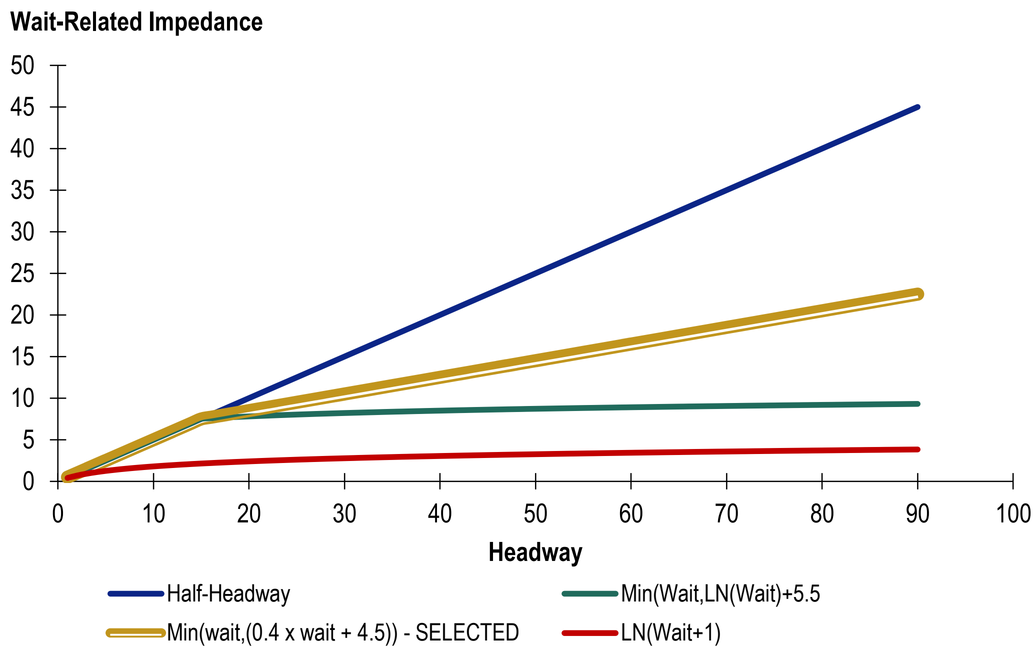
[18] MTC with Parsons Brinkerhoff, *Travel Model Development: Calibration and Validation, Technical Report – Draft*, May 17, 2012, Table 72.

unreasonable drive-transit paths. If there is a high parking cost in the destination zone, for example, the shortest generalized cost path with equal drive-access and in-vehicle time weights may result in a long drive-access time with a very short transit trip at the end. Initial calibration found that many of the drive-transit paths had very short transit in-vehicle times. To reduce the number of imbalanced paths, a weight was added to drive-access links in the skim procedure. The mode choice utility functions were not changed.

Transit Initial Wait Time Adjustment

The regional models estimate initial transit wait time as one-half the headway, which assumes random passenger arrivals and regular service. This is appropriate for high-frequency service. Commuter rail service cannot be considered high frequency, and it is not reasonable to assume that passengers arrive randomly for a commuter train with a well-published schedule and vehicle arrival notifications. However, it is important to distinguish between high- and low-frequency service, and the alternative utility should decrease as headway increases. The initial wait time curves considered are shown in Figure 7.2. The selected curve is in yellow.

Figure 7.2 Initial Wait Time Curve Comparison



The selected initial wait time curve $\mathrm{MIN}(\frac{h}{2}, 0.4 \times \frac{h}{2} + 4.5)$ was chosen because it assumes random arrivals for headways up to 15 minutes. For headways greater than 15 minutes, the wait time impedance increases more slowly than one-half the headway, but faster than the log formulations. The mode share for Commuter Rail increased with the revised initial wait time impedance function.

Transit In-Vehicle Time Discounts

In accordance with the FTA guidelines, the in-vehicle time of fixed guideway transit service with station and vehicle amenities and visible, reliable service may be discounted by as much as 25 percent. The commuter rail service in both MTC and SCAG regions meets most of these criteria. Accordingly, a 10-percent discount was applied to the Commuter Rail in-vehicle time in both the skimming procedure and the mode choice model. The in-vehicle time discount increased commuter rail mode share and increased the proportion of commuter rail time in the transit path.

Shadow Pricing at Key Park-and-Ride Facilities

The mode choice model does not support a fixed capacity to limit the number of trips using a particular park-and-ride facility. Instead, a shadow price was added to the parking cost to deter use of the facility when it was near the real capacity. The shadow price was set through an iterative process between mode choice and assignment.

Process for Calibrating the ASCs

The general procedure to calibrate the ASCs is as follows:

- Calculate mode shares using original ASCs.
- Compare the calculated shares with the target shares:
  - If the calculated shares exceed the target shares: decrease the associated ASC;
  - Otherwise, increase the associated ASC.
- Recalculate mode shares using the updated ASCs.

The generally accepted practice is to adjust the constant by adding the log of the target share to calculated share ratio.[19] Let β_j^0 be the ASC, S_j the target share, and $\widehat{S_j^0}$ the estimated share for alternative j in the initial iteration. The ASC for the next iteration (β_j^1) is calculated as follows:

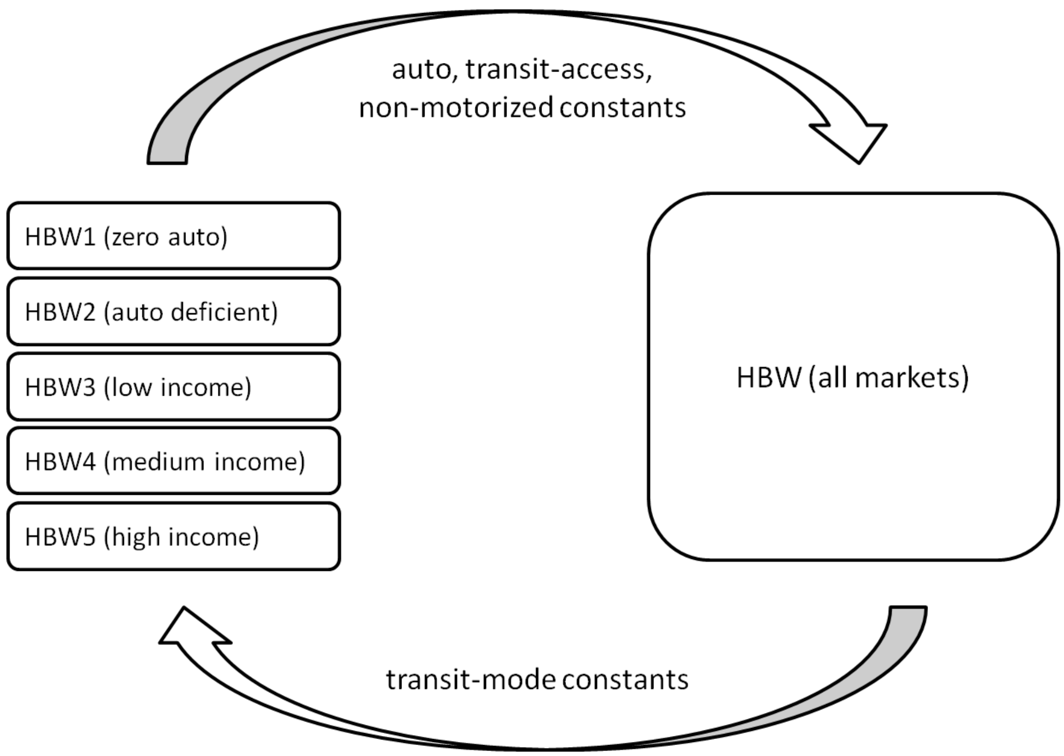
$$\beta_j^1 = \beta_j^0 + \ln\left(S_j/\widehat{S_j^0}\right)$$

To avoid overfitting the HBW market segments, the transit-mode ASCs are calibrated across all market segments while the transit access, auto occupancy,

[19] Train, Kenneth, 2009, *Discrete Choice Methods with Simulation*, Cambridge University Press, page 33.

and nonmotorized mode constants are calibrated for each market segment. To completely calibrate the model, an iterative process is necessary where the transit-mode constants are fixed and the transit access constants are calibrated. Then, the transit access constants are fixed and the transit-mode constants are calibrated. Figure 7.3 shows the calibration process for HBW market segments. Each block represents a calibration phase. Note that only the transit-mode constants are calibrated in the HBW *(*all markets*)* block; and only the auto, transit-access, and nonmotorized constants are calibrated in each of the individual market segment blocks on the left.

Figure 7.3 Home-Based Work Calibration Process



For the home-based nonwork and nonhome-based trip purposes, auto, transit-access, nonmotorized, and transit-mode constants are calibrated independently across the trip purposes.

Intra-SCAG Calibration Results

Table 7.19 and Table 7.20 show the mode share targets and model results, respectively. The transit-mode shares shown are the share of transit trips across both access modes. Model results (Table 7.20) are highlighted in yellow, where the model is more than one percentage point different from the target share. The model could not be calibrated to fit the target BRT share for HBW off-peak. This was due to the BRT constant being constrained to be less than or equal to the CVR constant.

Table 7.21 shows the calibrated ASCs at the motorized nest level. Constants with an absolute magnitude greater than 5 are highlighted in yellow. Several HBW medium- and high-income drive-transit alternative constants are less than -5, but their absolute magnitude is less than 7.

Table 7.22 shows the effective constant for each transit-mode by access mode at the motorized nest level. In Table 7.23, the constants are converted into IVTT equivalent units. For comparison, Local Bus is normalized to zero for each access-mode. Auto and nonmotorized modes are compared to the Local Bus Walk alternative. Drive to transit alternatives are compared to the Local Bus Drive alternative.

Table 7.19 Intra-SCAG Mode Choice Targets

	Mode Share							Share of Transit Trips					
	SOV	SR2	SR3	TWalk	TDrive	Walk	Bicycle	LOCB	EXPB	TBUS	BRT	URBR	CVR
Peak													
HBW-0 Auto	2.84%	12.98%	8.55%	55.30%	10.10%	6.60%	3.63%	66.78%	4.21%	3.82%	0.88%	17.13%	7.17%
HBW-Auto<Workers	35.62%	18.57%	9.90%	26.22%	1.95%	6.89%	0.84%						
HBW-Low Income	60.68%	7.22%	3.85%	22.73%	2.04%	3.07%	0.39%						
HBW-Middle Income	83.65%	6.79%	3.74%	2.51%	0.43%	2.59%	0.29%						
HBW-High Income	92.49%	4.09%	1.04%	0.42%	0.58%	1.25%	0.13%						
HBSH+O	38.06%	20.93%	26.97%	2.60%	0.18%	10.40%	0.87%	68.42%	3.09%	4.23%	0.85%	21.22%	2.19%
HBSR	27.78%	32.87%	27.86%	1.43%	0.18%	8.99%	0.88%	67.27%	2.76%	4.87%	1.61%	21.19%	2.30%
NHB-W	84.23%		7.69%	2.01%	0.32%	2.82%	2.94%	69.30%	3.33%	3.14%	0.71%	21.71%	1.81%
NHB-O	56.68%		35.57%	0.49%	0.03%	6.76%	0.48%	73.68%	2.41%	3.46%	0.41%	19.10%	0.94%
Off-Peak													
HBW-0 Auto	3.25%	9.13%	9.14%	59.02%	6.37%	9.38%	3.70%	71.18%	2.37%	3.13%	3.31%	19.42%	0.59%
HBW-Auto<Workers	38.75%	19.47%	10.33%	20.10%	2.17%	8.22%	0.95%						
HBW-Low Income	63.85%	7.26%	3.68%	18.47%	2.51%	3.80%	0.43%						
HBW-Middle Income	84.09%	6.61%	3.56%	2.24%	0.33%	2.84%	0.31%						
HBW-High Income	92.67%	3.92%	0.98%	0.46%	0.50%	1.34%	0.14%						
HBSH+O	41.83%	20.19%	25.20%	1.95%	0.14%	9.64%	1.05%	82.28%	5.32%	2.57%	0.64%	8.69%	0.50%
HBSR	27.64%	32.85%	27.66%	0.81%	0.13%	10.00%	0.91%	80.70%	2.89%	4.14%	1.64%	10.08%	0.55%
NHB-W	82.55%		8.35%	1.53%	0.22%	6.26%	1.09%	85.27%	4.24%	3.17%	1.14%	5.68%	0.50%
NHB-O	66.77%		25.97%	0.34%	0.04%	6.37%	0.51%	89.21%	2.40%	1.64%	0.96%	5.46%	0.32%

Table 7.20 SCAG Mode Choice Results

	Mode Share							Share of Transit Trips					
	SOV	SR2	SR3	TWalk	TDrive	Walk	Bicycle	LOCB	EXPB	TBUS	BRT	URBR	CVR
Peak													
HBW-0 Auto	6.39%	12.89%	8.49%	54.69%	10.06%	3.86%	3.61%	67.11%	4.18%	3.80%	0.88%	16.99%	7.03%
HBW-Auto<Workers	38.87%	18.53%	9.88%	26.19%	1.97%	3.72%	0.84%						
HBW-Low Income	61.19%	7.19%	3.83%	22.34%	2.02%	3.05%	0.39%						
HBW-Middle Income	84.76%	6.79%	3.74%	2.52%	0.43%	1.47%	0.29%						
HBW-High Income	92.47%	4.09%	1.04%	0.42%	0.60%	1.25%	0.13%						
HBSH+O	37.26%	20.92%	26.96%	2.58%	0.18%	10.39%	1.70%	68.46%	3.09%	4.23%	0.85%	21.19%	2.18%
HBSR	27.76%	32.88%	27.87%	1.44%	0.18%	8.99%	0.88%	67.39%	2.75%	4.86%	1.60%	21.11%	2.29%
NHB-W	84.22%	0.00%	7.69%	2.01%	0.33%	2.82%	2.94%	69.41%	3.32%	3.14%	0.70%	21.63%	1.80%
NHB-O	56.68%	0.00%	35.57%	0.49%	0.03%	6.76%	0.48%	73.77%	2.41%	3.45%	0.41%	19.02%	0.93%
Off-Peak													
HBW-0 Auto	7.90%	9.12%	9.14%	58.93%	6.38%	4.84%	3.70%	73.56%	2.36%	3.12%	1.03%	19.34%	0.59%
HBW-Auto<Workers	42.87%	19.41%	10.30%	19.99%	2.17%	4.32%	0.94%						
HBW-Low Income	64.27%	7.23%	3.66%	18.17%	2.47%	3.77%	0.43%						
HBW-Middle Income	84.10%	6.61%	3.56%	2.24%	0.34%	2.84%	0.31%						
HBW-High Income	92.66%	3.92%	0.98%	0.46%	0.50%	1.34%	0.14%						
HBSH+O	41.10%	20.19%	25.19%	1.93%	0.14%	9.64%	1.82%	82.29%	5.31%	2.57%	0.64%	8.68%	0.50%
HBSR	27.63%	32.85%	27.66%	0.81%	0.13%	10.01%	0.91%	80.72%	2.88%	4.14%	1.63%	10.08%	0.55%
NHB-W	82.57%	0.00%	8.35%	1.52%	0.22%	6.25%	1.09%	85.22%	4.27%	3.18%	1.14%	5.70%	0.51%
NHB-O	66.77%	0.00%	25.97%	0.34%	0.04%	6.37%	0.51%	89.21%	2.40%	1.63%	0.96%	5.47%	0.33%

Table 7.21 SCAG Alternative Constants at the Motorized Nest Level

	Auto			Transit-Access		Nonmotorized		Transit-Mode					
	SOV	SR2	SR3+	Walk	Drive	Walk	Drive	LOCB	EXPB	TBUS	BRT	URBR	CVR
Peak													
HBW-0 Auto	0.00	0.07	-0.58	4.27	1.92	7.00	0.23	0.00	-0.14	-0.30	0.36	0.35	1.34
HBW-Auto<Workers	0.00	-1.07	-2.15	1.48	-2.51	7.00	-2.80	0.00	-0.14	-0.30	0.36	0.35	1.34
HBW-Low Income	0.00	-3.64	-4.45	0.46	-3.04	6.11	-4.83	0.00	-0.14	-0.30	0.36	0.35	1.34
HBW-Middle Income	0.00	-3.45	-4.28	-2.59	-6.13	5.00	-5.02	0.00	-0.14	-0.30	0.36	0.35	1.34
HBW-High Income	0.00	-3.49	-5.29	-3.98	-6.35	5.42	-5.41	0.00	-0.14	-0.30	0.36	0.35	1.34
HBSH+O	0.00	-1.28	-2.56	4.30	1.55	-0.53	-7.00	0.00	0.05	0.03	0.32	0.24	0.44
HBSR	0.00	-0.33	-0.96	1.10	-2.33	2.16	-4.67	0.00	0.10	0.18	0.48	0.46	0.71
NHB-W	0.00	0.00	-2.58	0.18	-2.88	-1.99	-4.00	0.00	-0.08	-0.17	0.32	0.71	0.81
NHB-O	0.00	0.00	-0.59	-2.59	-6.00	-0.57	-5.58	0.00	0.45	-0.08	0.84	0.09	1.04
Off-Peak													
HBW-0 Auto	0.00	-0.47	-0.68	-3.70	-5.84	7.00	0.05	0.00	0.00	-0.35	0.76	0.44	0.76
HBW-Auto<Workers	0.00	-1.09	-2.17	-1.09	-2.84	7.00	-2.83	0.00	0.00	-0.35	0.76	0.44	0.76
HBW-Low Income	0.00	-3.61	-4.39	-0.18	-2.24	6.27	-4.80	0.00	0.00	-0.35	0.76	0.44	0.76
HBW-Middle Income	0.00	-3.38	-4.19	-1.60	-2.78	6.04	-4.94	0.00	0.00	-0.35	0.76	0.44	0.76
HBW-High Income	0.00	-3.45	-5.26	-0.55	-2.23	5.39	-5.37	0.00	0.00	-0.35	0.76	0.44	0.76
HBSH+O	0.00	-1.38	-2.70	-2.02	-4.10	-0.90	-7.00	0.00	0.21	-0.04	0.34	0.10	0.44
HBSR	0.00	-0.32	-0.95	-2.92	-5.87	2.42	-4.55	0.00	0.32	0.15	0.66	0.23	0.67
NHB-W	0.00	0.00	-2.47	-2.13	-3.97	-1.19	-5.08	0.00	-0.13	-0.01	0.12	0.90	0.97
NHB-O	0.00	0.00	-1.09	-3.25	-5.23	-0.93	-5.73	0.00	0.19	-0.32	0.70	0.23	1.02

Table 7.22 SCAG Alternative Constants
Effective Constants at the Motorized Nest Level

	Auto			Local Bus		Express Bus		Transitway Bus		BRT		Urban Rail		Commuter Rail		Nonmotorized	
	SOV	SR2	SR3+	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Bicycle
Peak																	
HBW-0 Auto	0.00	0.07	-0.58	4.27	1.92	4.13	1.78	3.97	1.62	4.63	2.28	4.62	2.27	5.60	3.25	7.00	0.23
HBW-Auto<Workers	0.00	-1.07	-2.15	1.48	-2.51	1.34	-2.65	1.18	-2.81	1.84	-2.15	1.83	-2.16	2.81	-1.18	7.00	-2.80
HBW-Low Income	0.00	-3.64	-4.45	0.46	-3.04	0.32	-3.17	0.15	-3.34	0.82	-2.67	0.81	-2.68	1.79	-1.70	6.11	-4.83
HBW-Middle Income	0.00	-3.45	-4.28	-2.59	-6.13	-2.72	-6.26	-2.89	-6.43	-2.22	-5.76	-2.23	-5.77	-1.25	-4.79	5.00	-5.02
HBW-High Income	0.00	-3.49	-5.29	-3.98	-6.35	-4.12	-6.48	-4.28	-6.65	-3.62	-5.98	-3.63	-5.99	-2.65	-5.01	5.42	-5.41
HBSH+O	0.00	-1.28	-2.56	-1.09	-2.84	-1.04	-2.78	-1.06	-2.80	-0.77	-2.52	-0.86	-2.60	-0.65	-2.39	-0.53	-7.00
HBSR	0.00	-0.33	-0.96	-0.18	-2.24	-0.08	-2.14	0.00	-2.06	0.30	-1.76	0.28	-1.79	0.53	-1.53	2.16	-4.67
NHB-W	0.00		-2.58	-2.02	-4.10	-2.10	-4.19	-2.19	-4.27	-1.70	-3.79	-1.31	-3.40	-1.21	-3.29	-1.99	-4.00
NHB-O	0.00		-0.59	-2.92	-5.87	-3.05	-6.00	-2.92	-5.88	-2.79	-5.75	-2.02	-4.97	-1.94	-4.90	-0.57	-5.58
Off-Peak																	
HBW-0 Auto	0.00	-0.47	-0.68	4.30	1.55	4.30	1.55	3.94	1.19	5.06	2.31	4.74	1.99	5.06	2.31	7.00	0.05
HBW-Auto<Workers	0.00	-1.09	-2.17	1.10	-2.33	1.10	-2.33	0.74	-2.68	1.86	-1.57	1.54	-1.89	1.86	-1.57	7.00	-2.83
HBW-Low Income	0.00	-3.61	-4.39	0.18	-2.88	0.18	-2.88	-0.18	-3.24	0.94	-2.12	0.62	-2.44	0.94	-2.12	6.27	-4.80
HBW-Middle Income	0.00	-3.38	-4.19	-2.59	-6.00	-2.59	-5.99	-2.95	-6.35	-1.83	-5.23	-2.15	-5.55	-1.83	-5.23	6.04	-4.94
HBW-High Income	0.00	-3.45	-5.26	-3.70	-5.84	-3.70	-5.84	-4.05	-6.20	-2.94	-5.08	-3.26	-5.40	-2.94	-5.08	5.39	-5.37
HBSH+O	0.00	-1.38	-2.70	-1.60	-2.78	-1.39	-2.58	-1.64	-2.82	-1.26	-2.44	-1.50	-2.68	-1.16	-2.35	-0.90	-7.00
HBSR	0.00	-0.32	-0.95	-0.55	-2.23	-0.23	-1.91	-0.40	-2.08	0.11	-1.57	-0.32	-2.00	0.12	-1.56	2.42	-4.55
NHB-W	0.00		-2.47	-2.13	-3.97	-1.68	-3.52	-2.21	-4.05	-1.28	-3.12	-2.03	-3.88	-1.08	-2.93	-1.19	-5.08
NHB-O	0.00		-1.09	-3.25	-5.23	-3.06	-5.04	-3.57	-5.55	-2.56	-4.53	-3.03	-5.00	-2.23	-4.21	-0.93	-5.73

Table 7.23 SCAG Alternative Constant Effect in IVTT Normalized to Local Bus by Access Mode

	Auto			Local Bus		Express Bus		Transitway Bus		BRT		Urban Rail		Commuter Rail		Nonmotorized	
	SOV	SR2	SR3+	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Bicycle
Peak																	
HBW-0 Auto	178	175	202	0	0	6	6	13	13	-15	-15	-15	-15	-56	-56	-114	169
HBW-Auto<Workers	62	107	152	0	0	6	6	13	13	-15	-15	-15	-15	-56	-56	-231	179
HBW-Low Income	19	171	205	0	0	6	6	13	13	-15	-15	-15	-15	-56	-56	-236	221
HBW-Middle Income	-108	36	71	0	0	6	6	13	13	-15	-15	-15	-15	-56	-56	-317	102
HBW-High Income	-166	-21	55	0	0	6	6	13	13	-15	-15	-15	-15	-56	-56	-393	60
HBSH+O	-19	3	25	0	0	-1	-1	-1	-1	-5	-5	-4	-4	-8	-8	-10	102
HBSR	-6	6	29	0	0	-4	-4	-7	-7	-17	-17	-17	-17	-26	-26	-85	164
NHB-W	-62	-62	17	0	0	3	3	5	5	-10	-10	-22	-22	-25	-25	-1	61
NHB-O	-90	-90	-72	0	0	4	4	0	0	-4	-4	-28	-28	-30	-30	-73	82
Off-Peak																	
HBW-0 Auto	180	199	208	0	0	0	0	15	15	-32	-32	-18	-18	-32	-32	-113	177
HBW-Auto<Workers	46	91	136	0	0	0	0	15	15	-32	-32	-18	-18	-32	-32	-247	164
HBW-Low Income	8	158	191	0	0	0	0	15	15	-32	-32	-18	-18	-32	-32	-255	208
HBW-Middle Income	-108	33	67	0	0	0	0	15	15	-32	-32	-18	-18	-32	-32	-361	98
HBW-High Income	-155	-10	65	0	0	0	0	15	15	-32	-32	-18	-18	-32	-32	-380	70
HBSH+O	-28	-4	19	0	0	-4	-4	1	1	-6	-6	-2	-2	-8	-8	-12	93
HBSR	-20	-8	15	0	0	-12	-12	-5	-5	-24	-24	-8	-8	-24	-24	-108	146
NHB-W	-66	-66	11	0	0	-14	-14	2	2	-26	-26	-3	-3	-32	-32	-29	92
NHB-O	-101	-101	-67	0	0	-6	-6	10	10	-22	-22	-7	-7	-32	-32	-72	77

Average Trip Length

Two primary reasonableness checks were conducted on the mode choice results: 1) average trip length by mode and 2) mode share by distances. Transit assignment boardings were also examined as discussed in Section 8.2.

Figure 7.4 and Figure 7.5 show the average trip length by mode and trip purpose for the peak and off-peak periods, respectively. As expected, Commuter Rail has the longest average trip length.

Figure 7.4 Intra-SCAG Average Trip Length - Peak

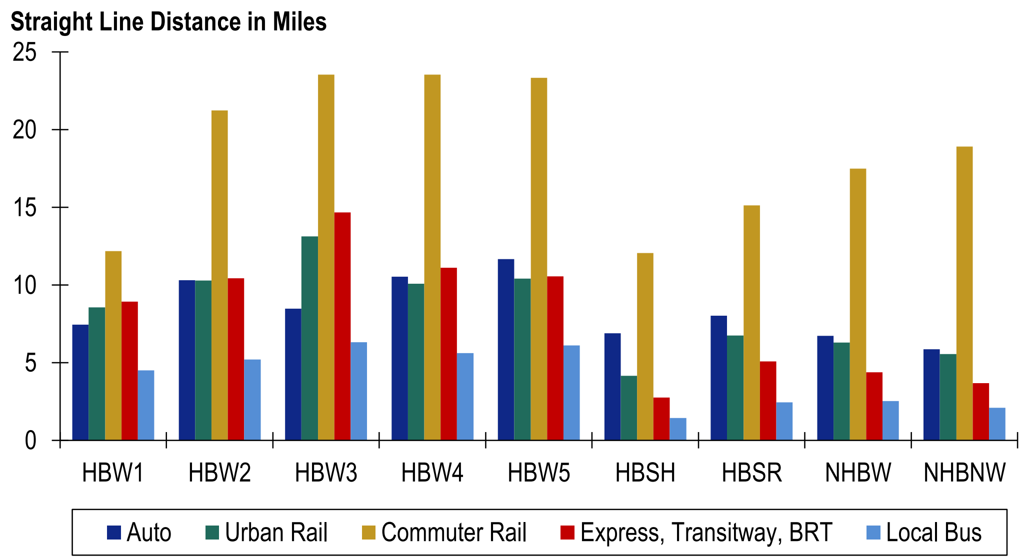
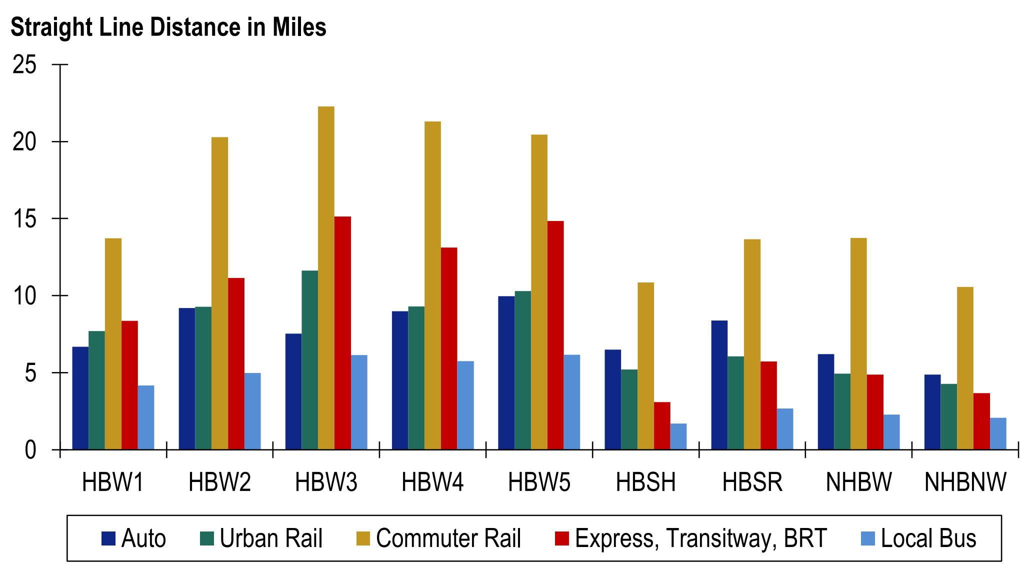


Figure 7.5 Intra-SCAG Average Trip Length – Off-Peak



Mode Share by Distance

Figure 7.6 and Figure 7.7 show the transit mode shares by three distance ranges: less than 5 miles, between 5 and 15 miles, and greater than 15 miles. Across all purposes, local bus is the dominant transit mode for shorter trips; and urban rail, express bus, and commuter rail are used more on longer trips. This pattern is consistent in the peak and off-peak.

Figure 7.6 Intra-SCAG Transit Mode Share by Distance - Peak

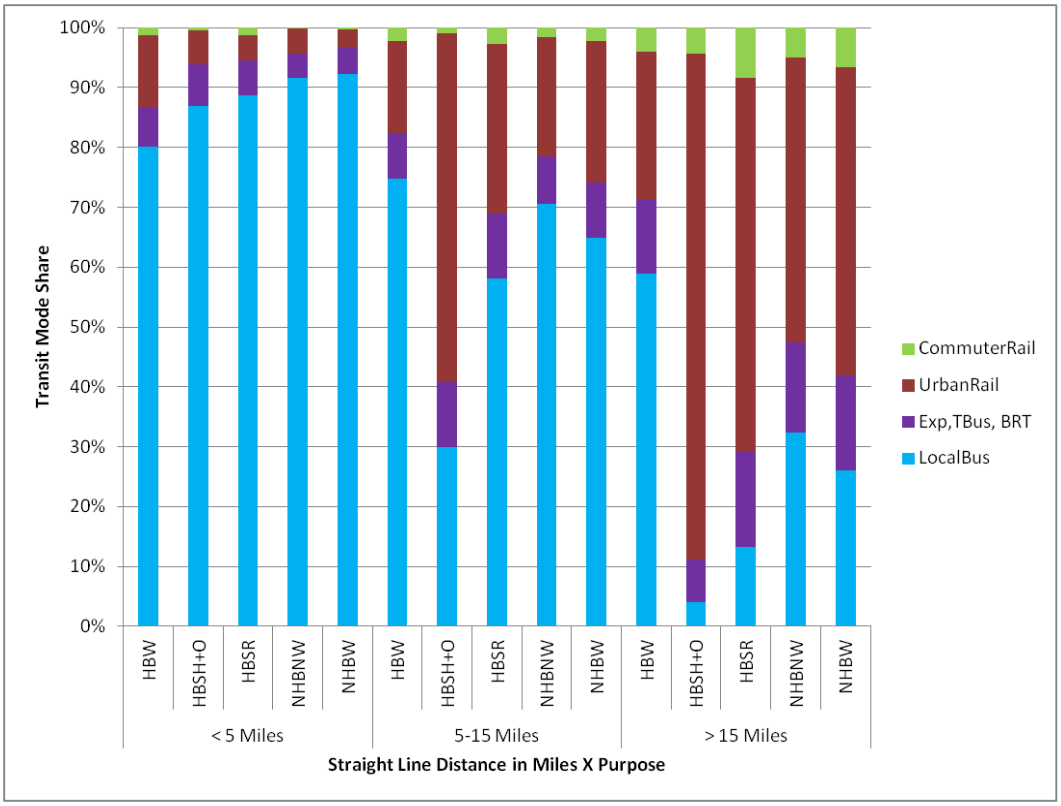
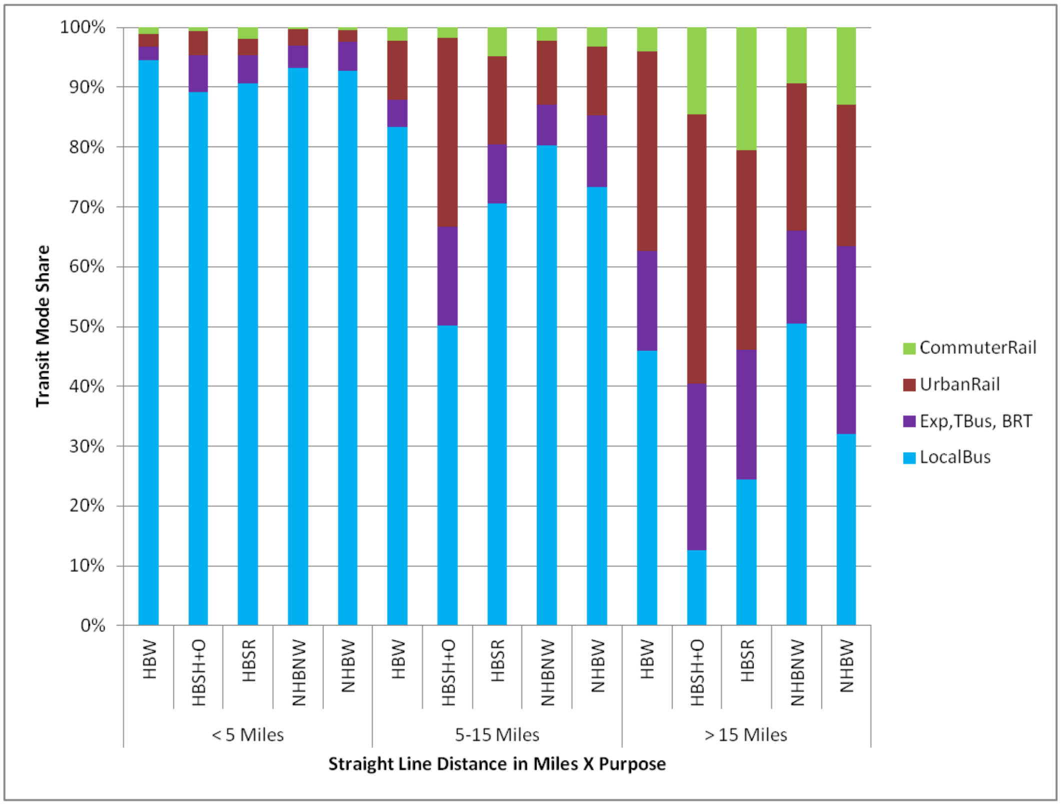


Figure 7.7 Intra-SCAG Transit Mode Share by Distance - Offpeak



Intra-MTC Calibration Results

Table 7.24 and Table 7.25 show the mode share targets and model results, respectively. The transit-mode shares shown are the share of transit trips across both access modes. Model results (Table 7.25) are highlighted in yellow where the model is more than 1 percentage point different from the target share.

Table 7.26 shows the calibrated ASCs at the motorized nest level. Constants with an absolute magnitude greater than 5 are highlighted in yellow. These are almost exclusively nonmotorized mode constants. While this may make the model less sensitive for these types of trips, it will not impact the area of interest for HSR study, which has much longer trip distances than either walk or bike.

Table 7.27 shows the effective constant for each transit-mode by access mode at the motorized nest level. In Table 7.28, the constants are converted into IVTT equivalent units. For comparison, Local Bus is normalized to zero for each access mode. Auto and nonmotorized modes are compared to the Local Bus Walk alternative. Drive to transit alternatives are compared to the Local Bus Drive alternative.

Table 7.24 MTC Mode Choice Targets

	Mode Share							Share of Transit Trips				
	SOV	SR2	SR3	TWalk	TDrive	Walk	Bicycle	LOCB	EXPB	LRT	URBR	CVR
Peak												
HBW-0 Auto	0.00%	9.43%	4.21%	53.99%	0.00%	26.18%	6.19%	32.96%	4.40%	16.28%	40.41%	5.46%
HBW-Auto<Workers	47.55%	13.48%	5.63%	13.68%	6.99%	8.44%	4.23%					
HBW-Low Income	72.43%	6.59%	3.41%	5.17%	4.72%	5.62%	2.05%					
HBW-Middle Income	72.15%	7.24%	3.65%	5.41%	5.04%	4.69%	1.82%					
HBW-High Income	72.85%	8.46%	4.16%	4.56%	6.49%	2.37%	1.12%					
HBSH+O	46.88%	19.43%	20.66%	2.40%	0.27%	9.26%	1.09%	58.84%	4.56%	16.08%	19.09%	1.24%
HBSR	37.67%	20.55%	24.27%	3.14%	0.46%	12.78%	1.13%	56.71%	5.38%	15.28%	21.08%	1.34%
NHB-W	75.55%		10.02%	3.27%	0.00%	10.48%	0.68%	60.33%	1.90%	16.27%	18.62%	2.59%
NHB-O	61.45%		27.19%	2.73%	0.00%	8.16%	0.47%	75.21%	0.83%	17.11%	6.60%	0.21%
Off-Peak												
HBW-0 Auto	0.00%	9.94%	4.08%	47.86%	0.00%	30.51%	7.62%	30.86%	3.47%	16.55%	44.09%	4.60%
HBW-Auto<Workers	48.92%	13.42%	5.38%	11.81%	6.83%	9.11%	4.54%					
HBW-Low Income	73.26%	6.67%	3.11%	4.36%	4.59%	5.74%	2.27%					
HBW-Middle Income	73.54%	7.24%	3.35%	4.47%	4.68%	4.82%	1.90%					
HBW-High Income	73.79%	8.33%	3.83%	3.78%	6.55%	2.52%	1.21%					
HBSH+O	50.44%	19.21%	16.95%	2.16%	0.28%	9.79%	1.18%	56.75%	4.12%	17.42%	20.49%	1.06%
HBSR	41.45%	20.10%	20.22%	2.97%	0.50%	13.51%	1.26%	54.61%	4.89%	16.41%	23.00%	0.94%
NHB-W	61.45%		14.22%	1.40%	0.00%	22.15%	0.79%	60.62%	2.06%	19.91%	15.91%	1.28%
NHB-O	66.59%		23.65%	1.91%	0.00%	7.41%	0.43%	74.01%	0.94%	18.04%	6.82%	0.16%

Table 7.25 MTC Mode Choice Results

	Mode Share							Share of Transit Trips				
	SOV	SR2	SR3	TWalk	TDrive	Walk	Bicycle	LOCB	EXPB	LRT	URBR	CVR
Peak												
HBW1	16.20%	9.39%	4.19%	54.08%	0.03%	9.95%	6.15%	34.01%	4.36%	16.12%	40.10%	5.41%
HBW2	49.22%	13.46%	5.62%	13.85%	7.14%	6.50%	4.21%					
HBW3	72.43%	6.58%	3.40%	5.18%	4.76%	5.61%	2.04%					
HBW4	72.04%	7.23%	3.64%	5.47%	5.12%	4.69%	1.81%					
HBW5	72.63%	8.44%	4.15%	4.63%	6.65%	2.37%	1.12%					
HBSH+O	45.45%	19.43%	20.66%	2.42%	0.27%	9.27%	2.49%	59.17%	4.54%	15.98%	19.06%	1.24%
HBSR	37.63%	20.56%	24.27%	3.16%	0.47%	12.78%	1.13%	57.05%	5.36%	15.19%	21.06%	1.34%
NHBW	75.47%		10.02%	3.29%	0.05%	10.49%	0.68%	60.71%	1.90%	16.22%	18.59%	2.58%
NHBNW	61.39%		27.20%	2.74%	0.04%	8.16%	0.47%	68.16%	0.83%	17.06%	13.63%	0.33%
Off-Peak												
HBW1	16.59%	9.90%	4.06%	48.00%	0.04%	13.84%	7.58%	31.99%	3.43%	16.36%	43.67%	4.55%
HBW2	50.51%	13.39%	5.36%	11.97%	6.99%	7.25%	4.52%					
HBW3	73.28%	6.66%	3.11%	4.36%	4.61%	5.72%	2.25%					
HBW4	73.43%	7.23%	3.34%	4.53%	4.77%	4.82%	1.89%					
HBW5	73.56%	8.31%	3.82%	3.84%	6.74%	2.52%	1.21%					
HBSH+O	49.02%	19.22%	16.95%	2.18%	0.28%	9.79%	2.57%	57.13%	4.11%	17.26%	20.45%	1.05%
HBSR	41.40%	20.10%	20.22%	2.99%	0.50%	13.52%	1.26%	54.98%	4.87%	16.27%	22.96%	0.93%
NHBW	61.39%		14.22%	1.41%	0.04%	22.16%	0.79%	60.98%	2.06%	19.80%	15.88%	1.29%
NHBNW	66.55%		23.66%	1.92%	0.03%	7.42%	0.43%	67.16%	0.93%	17.99%	13.76%	0.16%

Table 7.26 MTC Alternative Constants at the Motorized Nest Level

	Auto			Transit-Access		Nonmotorized		Transit-Mode				
	SOV	SR2	SR3+	Walk	Drive	Walk	Bicycle	LOCB	EXPB	LRT	URBR	CVR
Peak												
HBW-0 Auto	0.00	-1.18	-2.29	1.03	-4.64	7.00	-1.40	0.00	-0.26	0.63	0.36	0.57
HBW-Auto<Workers	0.00	-1.59	-2.96	-0.72	-2.16	7.00	-1.92	0.00	-0.26	0.63	0.36	0.57
HBW-Low Income	0.00	-3.83	-4.75	-2.68	-3.29	5.41	-4.12	0.00	-0.26	0.63	0.36	0.57
HBW-Middle Income	0.00	-3.16	-3.91	-2.17	-3.19	6.00	-3.36	0.00	-0.26	0.63	0.36	0.57
HBW-High Income	0.00	-2.48	-3.49	-1.58	-2.78	6.32	-3.08	0.00	-0.26	0.63	0.36	0.57
HBSH+O	0.00	-1.38	-2.57	-4.04	-3.49	-1.04	-7.00	0.00	0.29	0.18	0.05	0.35
HBSR	0.00	-1.07	-1.26	-0.96	-2.04	1.93	-4.95	0.00	0.28	0.36	0.10	0.32
NHB-W	0.00	0.00	-2.21	-1.31	-4.70	-0.17	-5.46	0.00	-0.22	0.51	0.01	0.57
NHB-O	0.00	0.00	-1.65	-2.05	-5.03	0.47	-5.26	0.00	0.51	0.65	0.02	1.46
Off-Peak												
HBW-0 Auto	0.00	-1.14	-2.30	0.56	-4.64	7.00	-1.49	0.00	-0.14	0.64	0.38	0.98
HBW-Auto<Workers	0.00	-1.61	-3.00	-0.90	-2.20	7.00	-1.92	0.00	-0.14	0.64	0.38	0.98
HBW-Low Income	0.00	-3.82	-4.73	-3.04	-3.43	5.19	-4.19	0.00	-0.14	0.64	0.38	0.98
HBW-Middle Income	0.00	-3.17	-3.97	-2.42	-3.31	5.94	-3.38	0.00	-0.14	0.64	0.38	0.98
HBW-High Income	0.00	-2.50	-3.54	-1.69	-2.71	6.31	-3.03	0.00	-0.14	0.64	0.38	0.98
HBSH+O	0.00	-1.46	-2.82	-4.23	-3.56	-1.00	-7.00	0.00	0.40	0.19	0.05	0.55
HBSR	0.00	-1.21	-1.50	-1.20	-2.22	1.90	-4.90	0.00	0.52	0.42	0.11	0.54
NHB-W	0.00	0.00	-0.94	-1.27	-4.57	-0.38	-5.81	0.00	-0.40	0.67	0.00	0.00
NHB-O	0.00	0.00	-1.18	-1.72	-4.96	-0.64	-6.01	0.00	0.24	0.68	0.00	0.54

Table 7.27 MTC Alternative Constants
Effective Constants at the Motorized Nest Level

	Auto			Local Bus		Express Bus		LRT		Urban Rail		Commuter Rail		Nonmotorized	
	SOV	SR2	SR3+	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Bicycle
Peak															
HBW-0 Auto	0.00	-1.18	-2.29	1.03	-4.64	0.77	-4.89	1.66	-4.01	1.39	-4.28	1.60	-4.07	7.00	-1.40
HBW-Auto<Workers	0.00	-1.59	-2.96	-0.72	-2.16	-0.98	-2.42	-0.09	-1.53	-0.36	-1.80	-0.15	-1.59	7.00	-1.92
HBW-Low Income	0.00	-3.83	-4.75	-2.68	-3.29	-2.93	-3.54	-2.05	-2.66	-2.32	-2.93	-2.10	-2.71	5.41	-4.12
HBW-Middle Income	0.00	-3.16	-3.91	-2.17	-3.19	-2.42	-3.44	-1.54	-2.56	-1.81	-2.83	-1.60	-2.62	6.00	-3.36
HBW-High Income	0.00	-2.48	-3.49	-1.58	-2.78	-1.84	-3.04	-0.95	-2.15	-1.22	-2.42	-1.01	-2.21	6.32	-3.08
HBSH+O	0.00	-1.38	-2.57	-4.04	-3.49	-3.75	-3.21	-3.86	-3.31	-3.99	-3.44	-3.68	-3.14	-1.04	-7.00
HBSR	0.00	-1.07	-1.26	-0.96	-2.04	-0.69	-1.77	-0.60	-1.68	-0.87	-1.95	-0.65	-1.73	1.93	-4.95
NHB-W	0.00		-2.21	-1.31	-4.70	-1.52	-4.92	-0.79	-4.19	-1.30	-4.69	-0.74	-4.13	-0.17	-5.46
NHB-O	0.00		-0.94	-1.27	-4.57	-1.67	-4.97	-0.60	-3.90	-1.27	-4.57	-1.27	-4.57	-0.38	-5.81
Off-Peak															
HBW-0 Auto	0.00	-1.14	-2.30	0.56	-4.64	0.42	-4.77	1.20	-4.00	0.93	-4.26	1.54	-3.66	7.00	-1.49
HBW-Auto<Workers	0.00	-1.61	-3.00	-0.90	-2.20	-1.04	-2.34	-0.26	-1.56	-0.53	-1.83	0.08	-1.22	7.00	-1.92
HBW-Low Income	0.00	-3.82	-4.73	-3.04	-3.43	-3.18	-3.57	-2.40	-2.79	-2.66	-3.06	-2.06	-2.46	5.19	-4.19
HBW-Middle Income	0.00	-3.17	-3.97	-2.42	-3.31	-2.55	-3.44	-1.78	-2.67	-2.04	-2.93	-1.44	-2.33	5.94	-3.38
HBW-High Income	0.00	-2.50	-3.54	-1.69	-2.71	-1.83	-2.85	-1.05	-2.07	-1.32	-2.34	-0.71	-1.73	6.31	-3.03
HBSH+O	0.00	-1.46	-2.82	-4.23	-3.56	-3.82	-3.16	-4.03	-3.36	-4.18	-3.51	-3.68	-3.01	-1.00	-7.00
HBSR	0.00	-1.21	-1.50	-1.20	-2.22	-0.67	-1.70	-0.77	-1.80	-1.08	-2.11	-0.66	-1.68	1.90	-4.90
NHB-W	0.00		-1.65	-2.05	-5.03	-1.53	-4.52	-1.40	-4.38	-2.03	-5.01	-0.58	-3.57	0.47	-5.26
NHB-O	0.00		-1.18	-1.72	-4.96	-1.48	-4.73	-1.04	-4.29	-1.72	-4.96	-1.17	-4.42	-0.64	-6.01

Table 7.28 MTC Alternative Constant Effect in IVTT Normalized to Local Bus by Access Mode

	Auto			Local Bus		Express Bus		LRT		Urban Rail		Commuter Rail		Nonmotorized	
	SOV	SR2	SR3+	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Drive	Walk	Bicycle
Peak															
HBW-0 Auto	43	92	139	0	0	11	11	-26	-26	-15	-15	-24	-24	-250	101
HBW-Auto<Workers	-30	36	93	0	0	11	11	-26	-26	-15	-15	-24	-24	-323	50
HBW-Low Income	-112	48	87	0	0	11	11	-26	-26	-15	-15	-24	-24	-338	60
HBW-Middle Income	-91	41	73	0	0	11	11	-26	-26	-15	-15	-24	-24	-341	50
HBW-High Income	-66	38	80	0	0	11	11	-26	-26	-15	-15	-24	-24	-330	63
HBSH+O	-69	-46	-25	0	0	-5	-5	-3	-3	-1	-1	-6	-6	-52	51
HBSR	-35	4	11	0	0	-10	-10	-13	-13	-3	-3	-12	-12	-105	145
NHB-W	-40	-40	28	0	0	7	7	-16	-16	0	0	-18	-18	-35	129
NHB-O	-39	-39	-10	0	0	12	12	-21	-21	0	0	0	0	-28	140
Off-Peak															
HBW-0 Auto	23	71	119	0	0	6	6	-27	-27	-16	-16	-41	-41	-269	86
HBW-Auto<Workers	-38	30	87	0	0	6	6	-27	-27	-16	-16	-41	-41	-330	43
HBW-Low Income	-127	32	71	0	0	6	6	-27	-27	-16	-16	-41	-41	-344	48
HBW-Middle Income	-101	31	65	0	0	6	6	-27	-27	-16	-16	-41	-41	-349	40
HBW-High Income	-71	34	77	0	0	6	6	-27	-27	-16	-16	-41	-41	-334	56
HBSH+O	-73	-48	-24	0	0	-7	-7	-3	-3	-1	-1	-9	-9	-55	48
HBSR	-44	0	11	0	0	-19	-19	-15	-15	-4	-4	-20	-20	-113	135
NHB-W	-63	-63	-12	0	0	-16	-16	-20	-20	-1	-1	-45	-45	-78	99
NHB-O	-53	-53	-17	0	0	-7	-7	-21	-21	0	0	-17	-17	-33	133

Average Trip Length

Two primary reasonableness checks were conducted on the mode choice results: average trip length by mode and mode share by distance. Transit assignment boardings also were examined, as discussed in Section 8.2.

Figure 7.8 and Figure 7.9 show the average trip length by mode and trip purpose for the peak and off-peak periods, respectively. As expected, Commuter Rail has the longest average trip length followed by Urban Rail and LRT, with Local Bus having the shortest average trip length.

Figure 7.8 Intra-MTC Average Trip Length - Peak

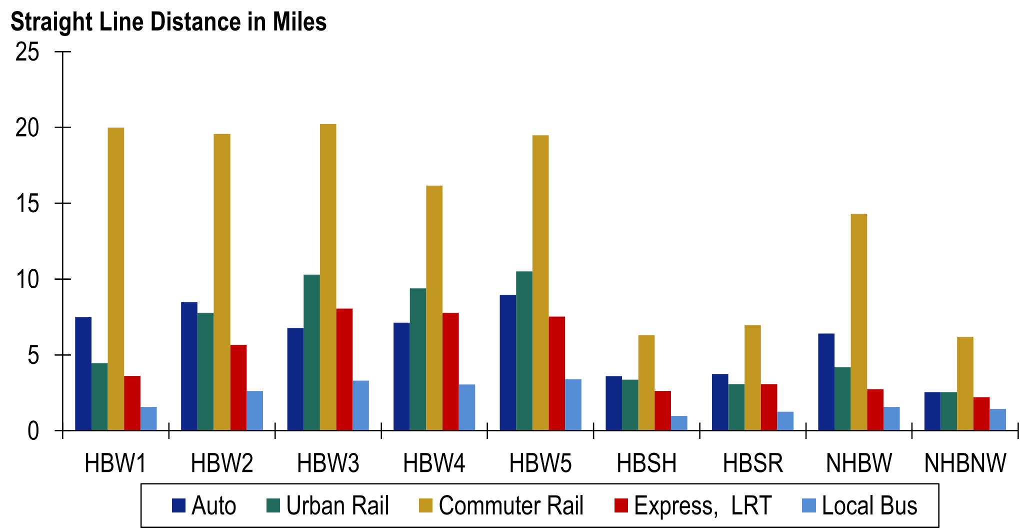
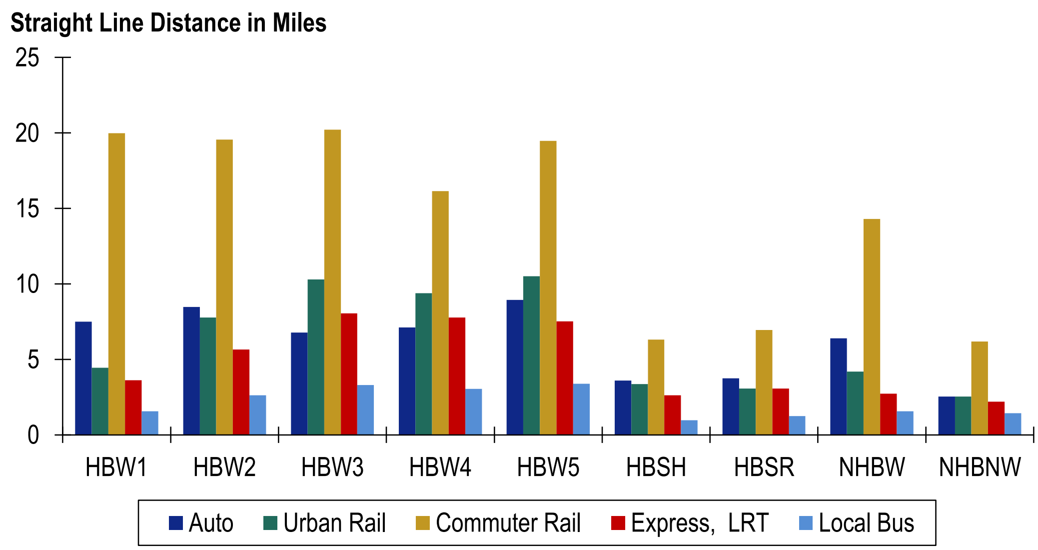


Figure 7.9 Intra-MTC Average Trip Length – Off-Peak



Mode Share by Distance

Figure 7.10 and Figure 7.11 show the transit mode shares by three distance ranges: less than 5 miles, between 5 and 15 miles, and greater than 15 miles. Across all purposes, local bus is the dominant transit mode for shorter trips; and urban rail, express bus, and commuter rail are used more on longer trips. This pattern is consistent in the peak and off-peak.

Figure 7.10 Intra-MTC Transit Mode Share by Distance – Peak

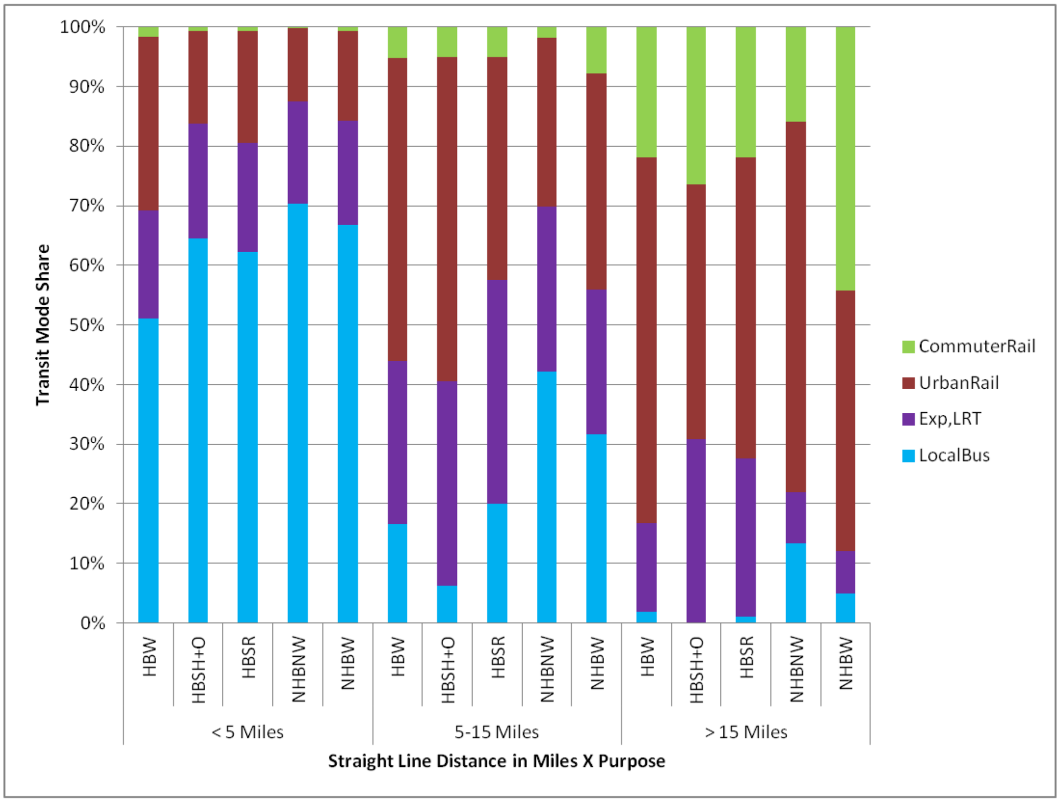
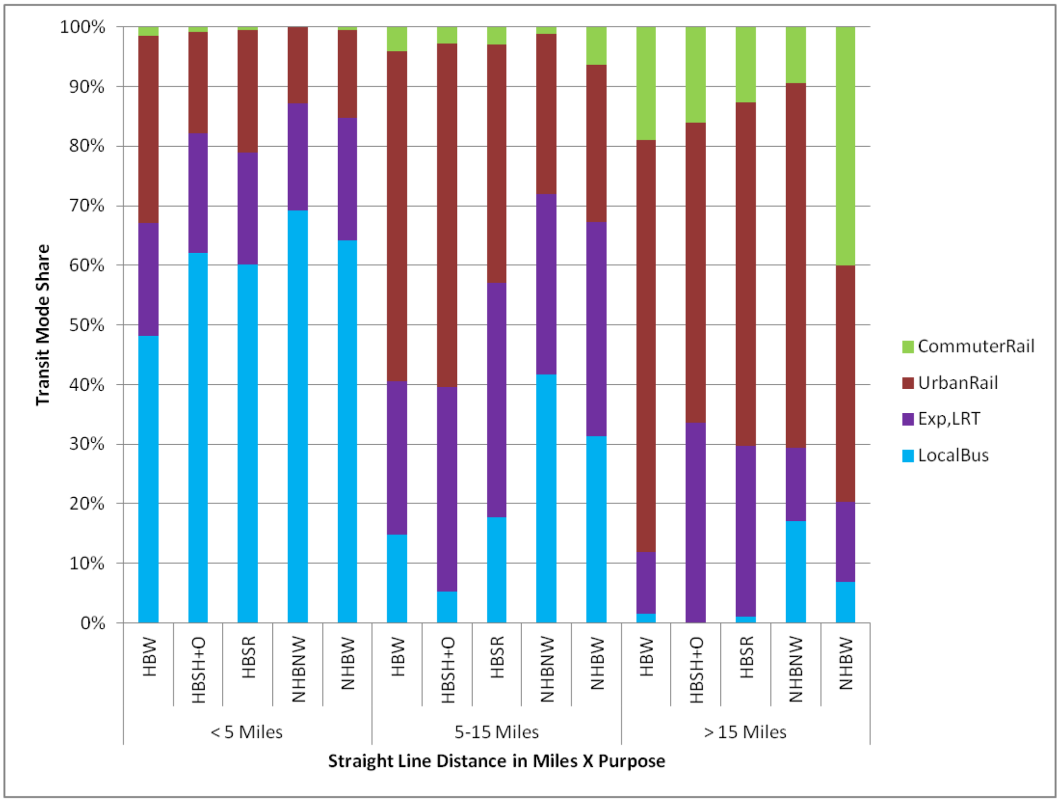


Figure 7.11 Intra-MTC Transit Mode Share by Distance – Off-Peak



8.0 Validation and Sensitivity Testing

8.1 Overview

After the model was calibrated, we validated it in three ways:

1. We compared model outcomes to the observed data, used for calibration, that are not directly affected by the calibrated constants. This included examining mode shares by distance and mode shares by household characteristics.
2. We compared CVR and air assignment results to observed boarding, segment volume, and OD data collected from transit operators and BTS.
3. We ran the model for a different year (2000) to validate the model's ability to be used for forecasting a different year. This is sometimes called a "backcast."

It should be noted that the concepts of model calibration and validation often are confused. After model constants have been adjusted so that modeled shares match observed shares for specified variables for a base year, the model is often labeled as being validated. This is really model calibration.

On the other hand, there is a component of model validation, or, at least, improved comfort with the veracity of the model, when modeled results reasonably match observed data for summaries not directly affected by the calibrated constants. Note that this is not independent data from those used to calibrate the model, just pieces of that data that did not directly affect the calibrated parameters.

A second type of validation compares model results for the base year with independently collected data. This is the more traditional definition of model validation. In this chapter, both types of validation are used with year 2010 data, as listed under Items 1 and 2 above.

In addition to validation, we performed a number of model runs for year 2010 to assess the model's sensitivity to various changes in LOS characteristics for different modes. This sensitivity testing included evaluating an HSR system that has similar LOS characteristics as the Northeast Corridor, and evaluating self- and cross-elasticities of LOS variables by adjusting one input variable at a time.

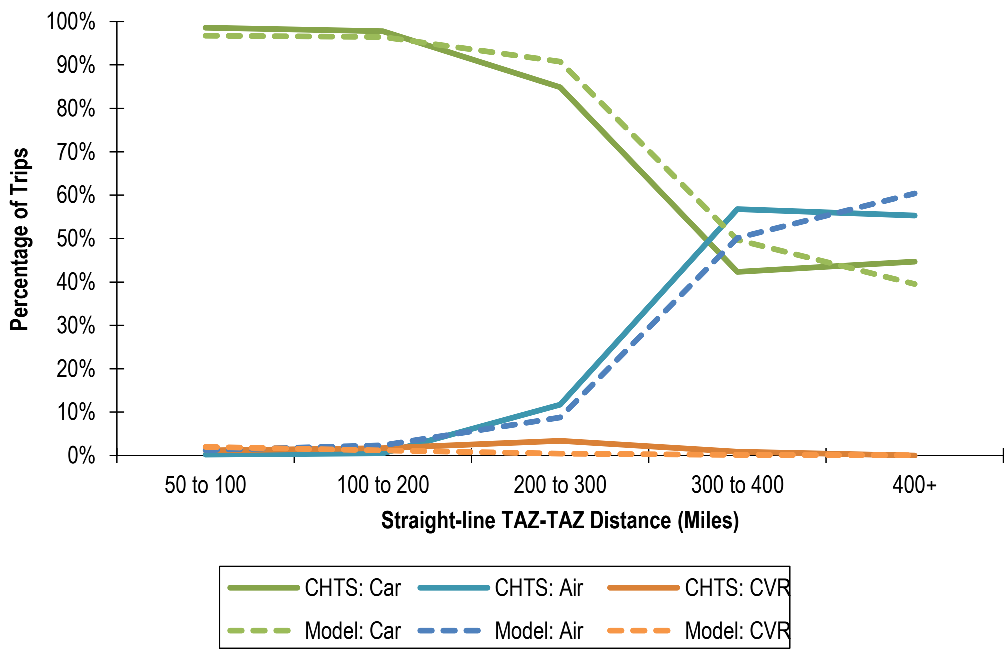
8.2 VALIDATION AGAINST YEAR 2010 OBSERVED DATA

We compared model outcomes to the observed CHTS data, used for calibration, which are not directly affected by the calibrated constants. This included examining mode shares by distance and mode shares by household characteristics.

Mode Shares by Distance

We first tested the model's forecast of main mode choice by travel distance compared to observed data. This travel characteristic was not addressed by the mode choice or trip distribution models. Figure 8.1 shows the CHTS and modeled mode shares by distance range for business trips. The modeled distributions match the observed CHTS distributions very well.

Figure 8.1 Mode Share by Distance Range Summary – Business



Commute purpose summaries for CHTS and the calibrated model, as shown in Figure 8.2, indicate the mode shares by distance range match reasonably well for shorter-distance commuter trips. Mode shares for longer-distance commute trips look a bit worse in comparison to observed data, primarily due to the lack of sufficient observed data in long-distance ranges for the commute purpose. Moreover, due to the low number of commute trips predicted to be in such long-distance ranges, matching CHTS is less critical for those trips.

Figure 8.2 Mode Share by Distance Range Summary – Commute

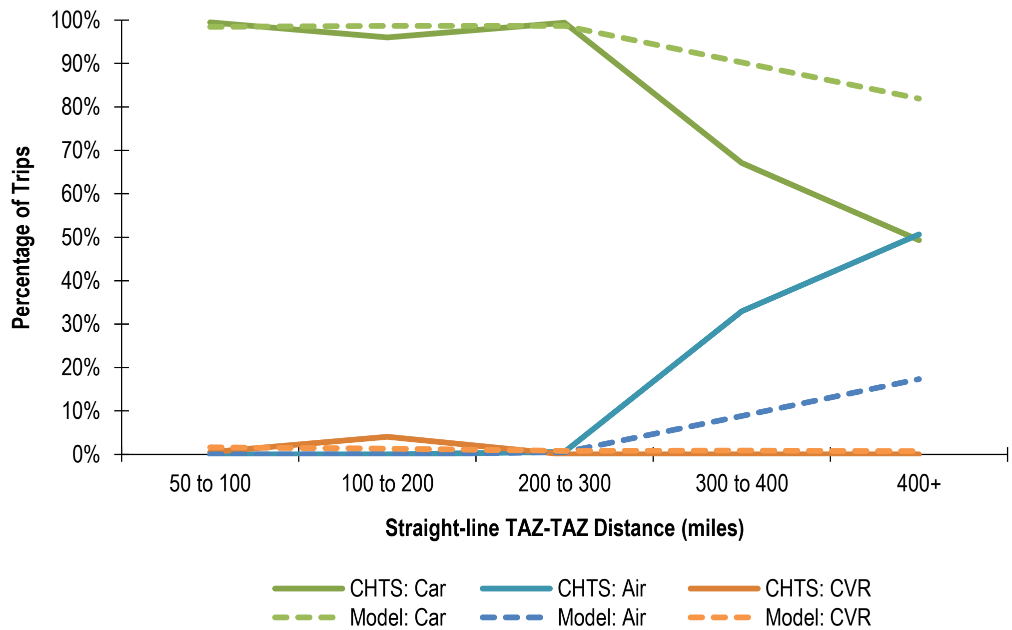


Figure 8.3 and Figure 8.4 show mode shares by distance for CHTS and the calibrated model for recreation and other trips, respectively. Similar to the business trip purpose, recreation and other trip mode shares appear to match observed data reasonably well for all distance ranges.

Figure 8.3 Mode Share by Distance Range Summary – Recreation

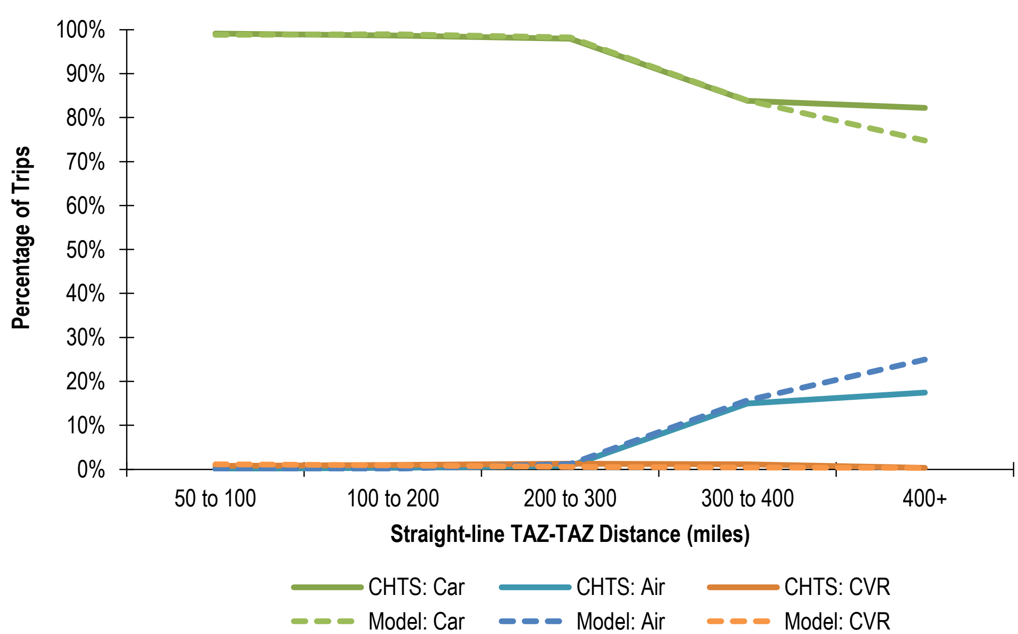
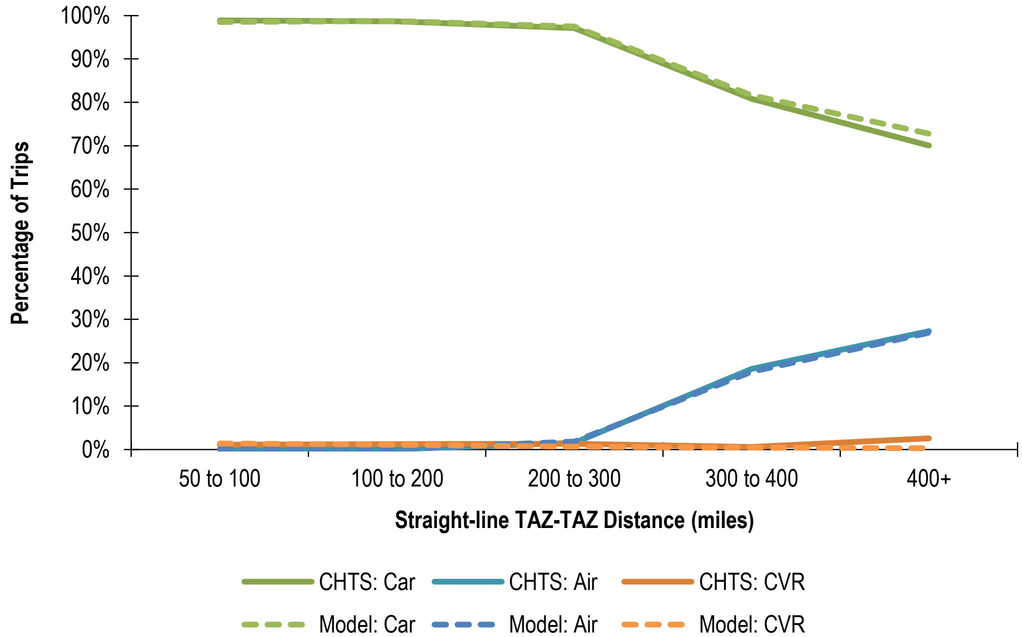


Figure 8.4 Mode Share by Distance Range Summary – Other



Overall, the modeled distributions for each trip purpose shown in the figures demonstrate that the distribution and mode choice models are producing reasonable results. The modeled average trip lengths by mode and purpose are also encouraging, as shown in Table 8.1. While the model generally underpredicted the average trip lengths of CVR trips, the observed average trip lengths for that mode were based on relatively few observations.

Table 8.1 Average Trip Lengths by Mode and Purpose
Miles

Average Trip Length (Miles)	CHTS				Calibrated Model				Difference				Percent Difference			
	Car	Air	CVR	Total	Car	Air	CVR	Total	Car	Air	CVR	Total	Car	Air	CVR	Total
Business	110	355	121	127	114	318	86	128	4	-37	-35	1	4%	-11%	-29%	1%
Commute	80	365	91	81	83	381	78	84	4	16	-13	3	4%	4%	-14%	4%
Recreation	113	328	132	115	111	356	96	114	-2	29	-35	-2	-2%	9%	-27%	-2%
Other	112	367	121	116	112	369	97	116	0	1	-27	0	0%	0%	-23%	0%

Trips by Household Attributes and Mode

We evaluated the model outcome of household attributes and mode, considering trip frequency, destination choice, and mode choice models. Since the trip frequency models forecast only total trips by purpose, summarizing the numbers of trips by mode and purpose for various household strata demonstrates the reasonableness of the overall modeling process.

Table 8.2, Table 8.3, Table 8.4, and Table 8.5 detail the summaries by trip purpose. The model results were compared to the CHTS data summaries. CHTS results are not shown explicitly in the tables, but the percent difference of model results to CHTS is shown. While the summaries show some rather large differences between modeled and observed trips by mode for the various strata, the largest differences tend to occur for socioeconomic strata with relatively few trips (and, by implication, households). In general, the greater the number of trips, the closer the model reproduces the observed data. This is not surprising, since the greater the number of trips, the more reflective that population segment is of the overall average, and the models replicate average behaviors quite well.

Table 8.2 Total Average Daily Household Trips by Household Attributes and Mode – Business

	Model				Percent Difference from CHTS			
	Car	AIR	CVR	Total	CAR	AIR	CVR	Total
Household Size								
One	19,482	1,049	342	20,872	17%	-50%	-25%	9%
Two	44,626	3,379	775	48,780	5%	-2%	14%	5%
Three	25,421	2,157	423	28,000	5%	35%	23%	7%
Four+	45,486	4,196	727	50,409	-12%	21%	36%	-9%
Total	**135,014**	**10,780**	**2,267**	**148,062**	**0%**	**2%**	**13%**	**0%**
Number of Workers								
Zero	14,754	614	231	15,598	7%	4%	158%	8%
One	52,230	3,626	880	56,736	-2%	-17%	-14%	-3%
Two+	68,030	6,541	1,157	75,727	1%	16%	28%	2%
Total	**135,014**	**10,780**	**2,267**	**148,062**	**0%**	**2%**	**13%**	**0%**
Household Income								
Low Income	19,039	263	245	19,547	14%	-20%	58%	14%
Medium Income	37,550	2,056	687	40,293	-5%	4%	-1%	-4%
High Income	78,425	8,460	1,335	88,221	0%	2%	15%	0%
Total	**135,014**	**10,780**	**2,267**	**148,062**	**0%**	**2%**	**13%**	**0%**

Table 8.3 Total Average Daily Household Trips by Household Attributes and Mode – Commute

	Model				Percent Difference from CHTS			
	Car	Air	CVR	Total	Car	Air	CVR	Total
Household Size								
One	22,951	50	343	23,344	-33%	-60%	100%	-32%
Two	65,624	197	1,054	66,875	12%	25%	-46%	10%
Three	46,173	142	730	47,045	2%	-21%	100%	4%
Four+	95,060	293	1,500	96,852	2%	83%	426%	3%
Total	**229,808**	**681**	**3,626**	**234,115**	**-1%**	**10%**	**63%**	**0%**
Number of Workers								
Zero	10,329	14	137	10,480	-11%	100%	100%	-10%
One	89,954	211	1,356	91,521	-17%	-5%	280%	-16%
Two+	129,525	456	2,133	132,114	17%	15%	15%	17%
Total	**229,808**	**681**	**3,626**	**234,115**	**-1%**	**10%**	**63%**	**0%**
Household Income								
Low Income	30,413	14	242	30,669	257%	-59%	100%	258%
Medium Income	65,255	92	1,116	66,463	-28%	-30%	-3%	-28%
High Income	134,140	576	2,268	136,983	2%	27%	112%	3%
Total	**229,808**	**681**	**3,626**	**234,115**	**-1%**	**10%**	**63%**	**0%**

Table 8.4 Total Average Daily Household Trips by Household Attributes and Mode – Recreation

	Model				Percent Difference from CHTX			
	Car	Air	CVR	Total	Car	Air	CVR	Total
Household Size								
One	54,782	1,047	1,329	57,157	39%	34%	-26%	36%
Two	123,048	1,671	1,544	126,263	0%	10%	25%	0%
Three	88,224	910	746	89,880	11%	34%	16%	11%
Four+	226,700	1,845	1,441	229,986	-10%	-7%	82%	-10%
Total	**492,754**	**5,473**	**5,059**	**503,286**	**0%**	**10%**	**13%**	**0%**
Number of Workers								
Zero	76,892	998	1,380	79,271	27%	148%	23%	28%
One	178,604	2,074	1,957	182,634	-7%	-3%	1%	-7%
Two+	237,258	2,401	1,723	241,382	-2%	-2%	23%	-1%
Total	492,754	5,473	5,059	503,286	0%	10%	13%	0%

	Model				Percent Difference from CHTX			
	Car	Air	CVR	Total	Car	Air	CVR	Total
Household Income								
Low Income	68,049	841	1,556	70,447	-1%	163%	76%	1%
Medium Income	138,875	1,375	1,450	141,700	3%	107%	-25%	3%
High Income	285,830	3,256	2,053	291,139	-2%	-18%	24%	-2%
Total	**492,754**	**5,473**	**5,059**	**503,286**	**0%**	**10%**	**13%**	**0%**

Table 8.5 Total Average Daily Household Trips by Household Attributes and Mode – Other

	Model				Percent Difference from CHTS			
	Car	Air	CVR	Total	Car	Air	CVR	Total
Household Size								
One	96,728	2,648	2,594	101,970	29%	6%	17%	28%
Two	166,444	3,568	2,457	172,470	-1%	6%	78%	0%
Three	101,370	1,632	994	103,996	-1%	-20%	-14%	-1%
Four+	234,690	2,896	1,669	239,254	-8%	25%	-30%	-8%
Total	**599,232**	**10,744**	**7,714**	**617,690**	**0%**	**5%**	**8%**	**0%**
Number of Workers								
Zero	138,270	2,612	2,832	143,713	19%	88%	19%	20%
One	232,895	4,273	3,010	240,178	-2%	6%	30%	-2%
Two+	228,068	3,860	1,872	233,799	-7%	-20%	-24%	-8%
Total	**599,232**	**10,744**	**7,714**	**617,690**	**0%**	**5%**	**8%**	**0%**
Household Income								
Low Income	136,977	2,261	3,276	142,514	9%	56%	89%	11%
Medium Income	186,204	2,587	2,192	190,982	-2%	-6%	-7%	-2%
High Income	276,052	5,897	2,246	284,194	-3%	-2%	-27%	-3%
Total	**599,232**	**10,744**	**7,714**	**617,690**	**0%**	**5%**	**8%**	**0%**

Conventional Rail Validation Measures

Another validation measure checked model results against independently collected conventional rail data. The model was estimated and calibrated based primarily on data from the 2012-2013 CHTS. In this section, observed conventional rail passenger loads by link, obtained from each respective conventional rail operator, are compared to modeled loads.

Figure 8.5 shows daily passenger loads for the Amtrak Capitol Corridor route from the Sacramento area to San Jose. Modeled loads match observed loads quite well, though are a little low from Sacramento to Berkeley. Figure 8.6 shows modeled versus observed loads for the ACE service from Stockton to San Jose. Of all the conventional rail comparisons, this particular corridor is the worst in terms of matching observed loads.

Figure 8.5 Amtrak Capitol Corridor Route: Average_Daily Loads (from 2010 City-to-City Volumes)

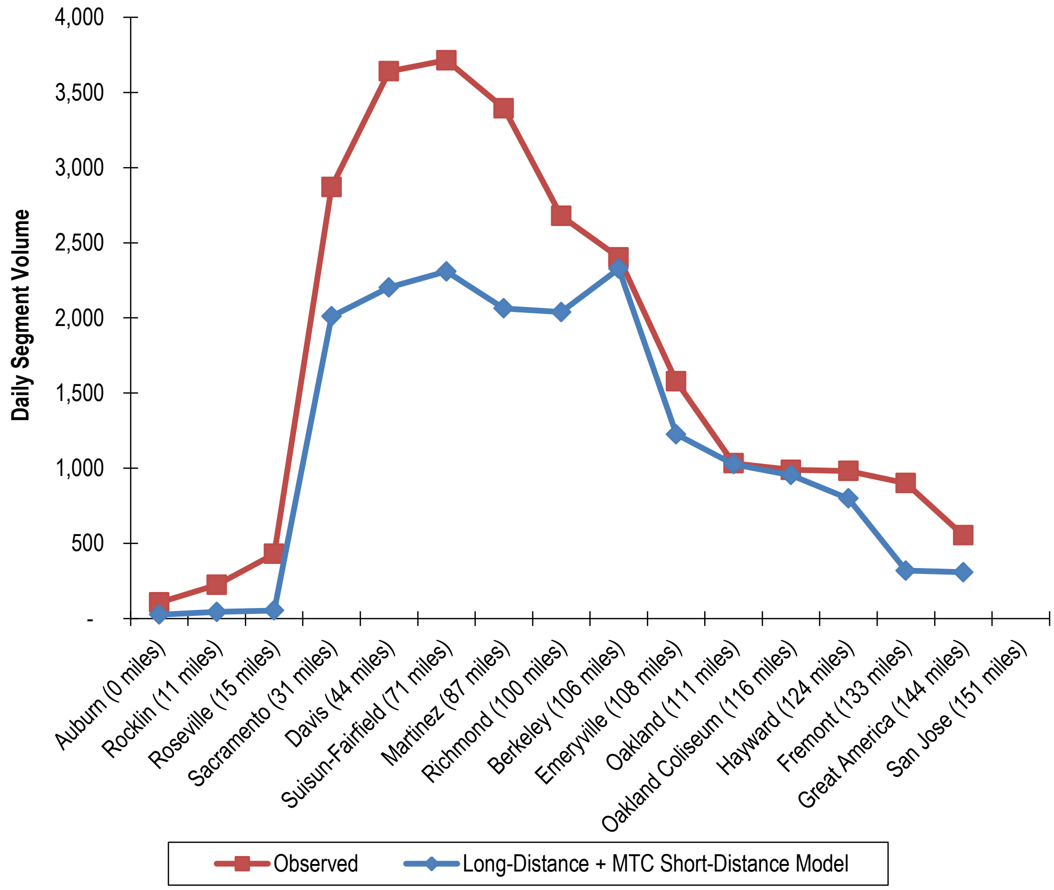


Figure 8.6 ACE: Average Daily Loads (Observed Data Derived from 2010 On/Off Volumes)

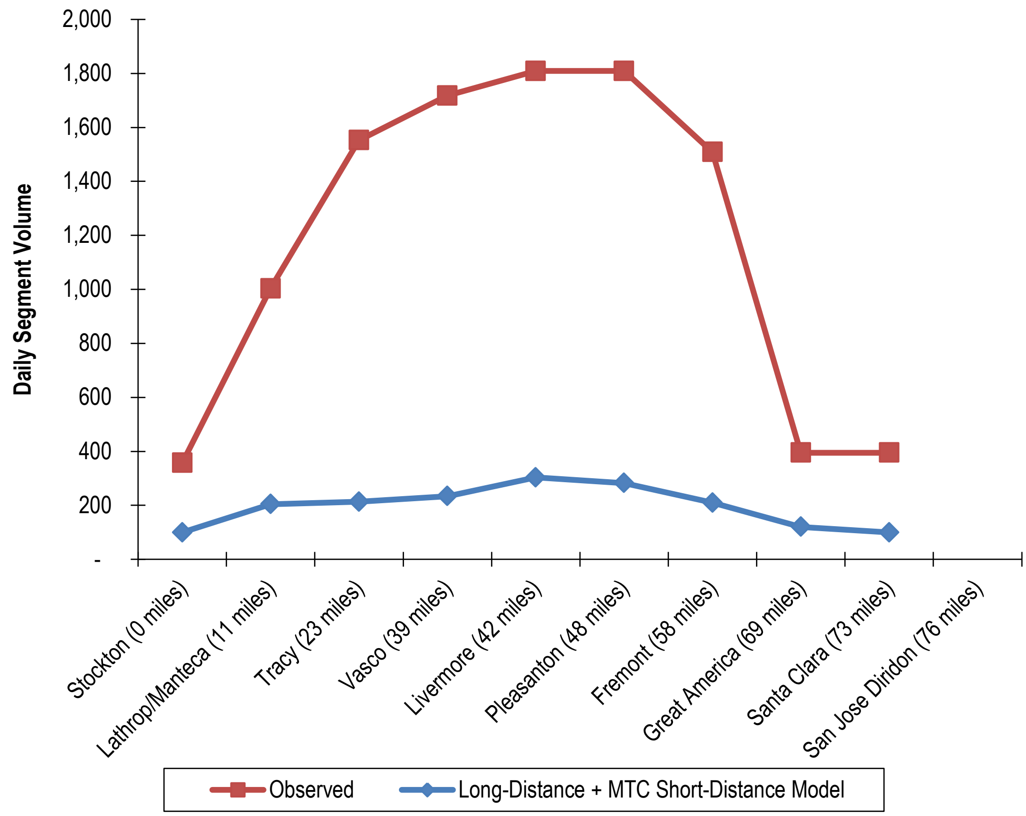


Figure 8.7 shows Caltrain daily loads. Caltrain runs from downtown San Francisco south along the San Francisco Peninsula to San Jose and continues to Gilroy. Modeled volumes reasonably match observed counts.

Figure 8.7 Caltrain: Average Daily Loads (from 2010 City-to-City Volumes)

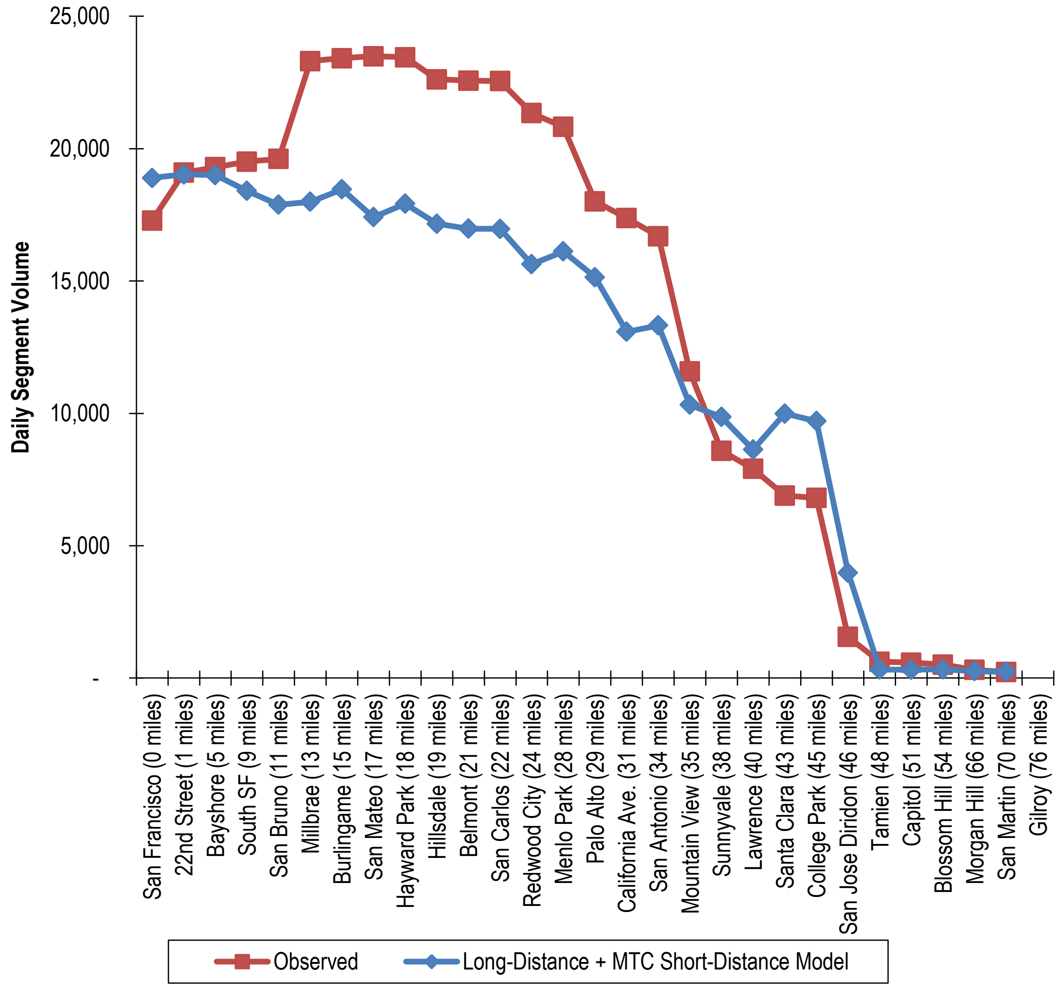


Figure 8.8 shows Amtrak's San Joaquin route running from Bakersfield to Lodi (just south of Sacramento). Model volumes are slightly low across the board compared to observed (from 2010 City-to-City data), but in general, track the observed volumes. Figure 8.9 shows Amtrak's Pacific Surfliner route, running from San Diego, through Los Angeles to San Luis Obispo. Again, modeled conventional rail trips match the observed (from 2010 City-to-City data) very well.

Figure 8.8 Amtrak San Joaquin Route: Average Daily Loads (from 2010 City-to-City Volumes)

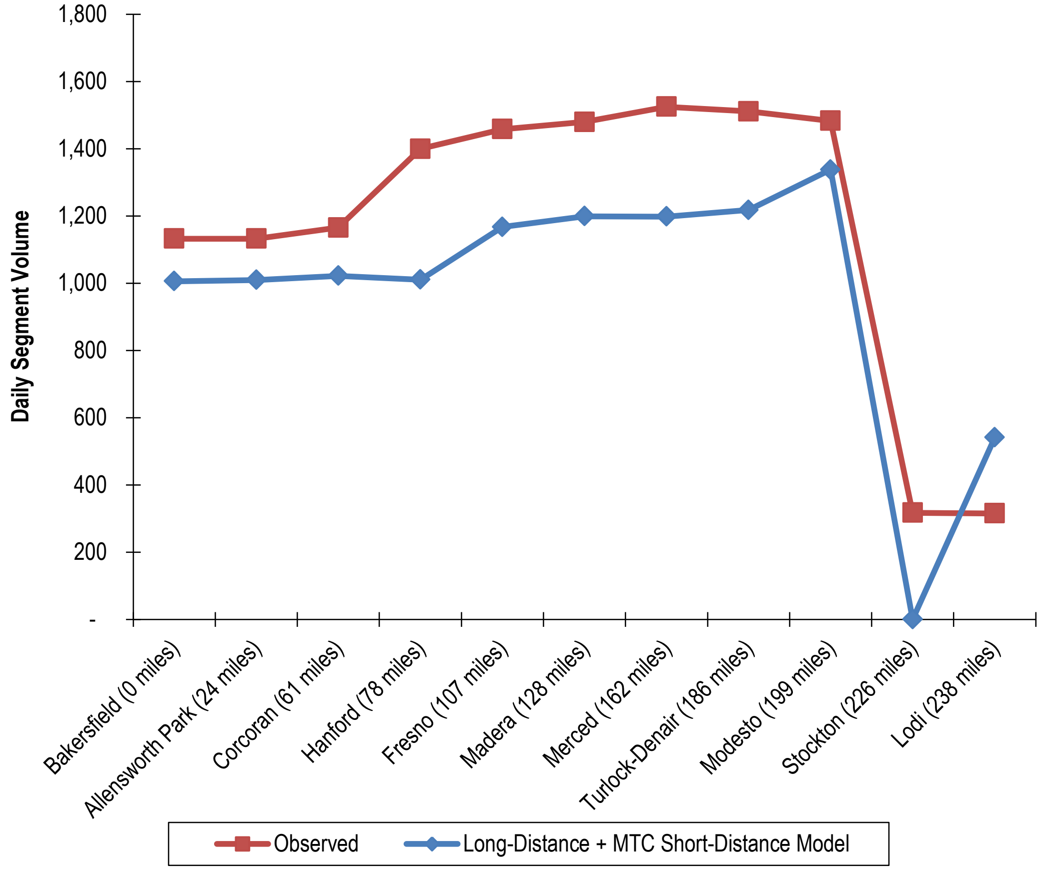


Figure 8.9 Amtrak Pacific Surfliner Route: Average Daily Loads (from 2010 City-to-City Volumes)

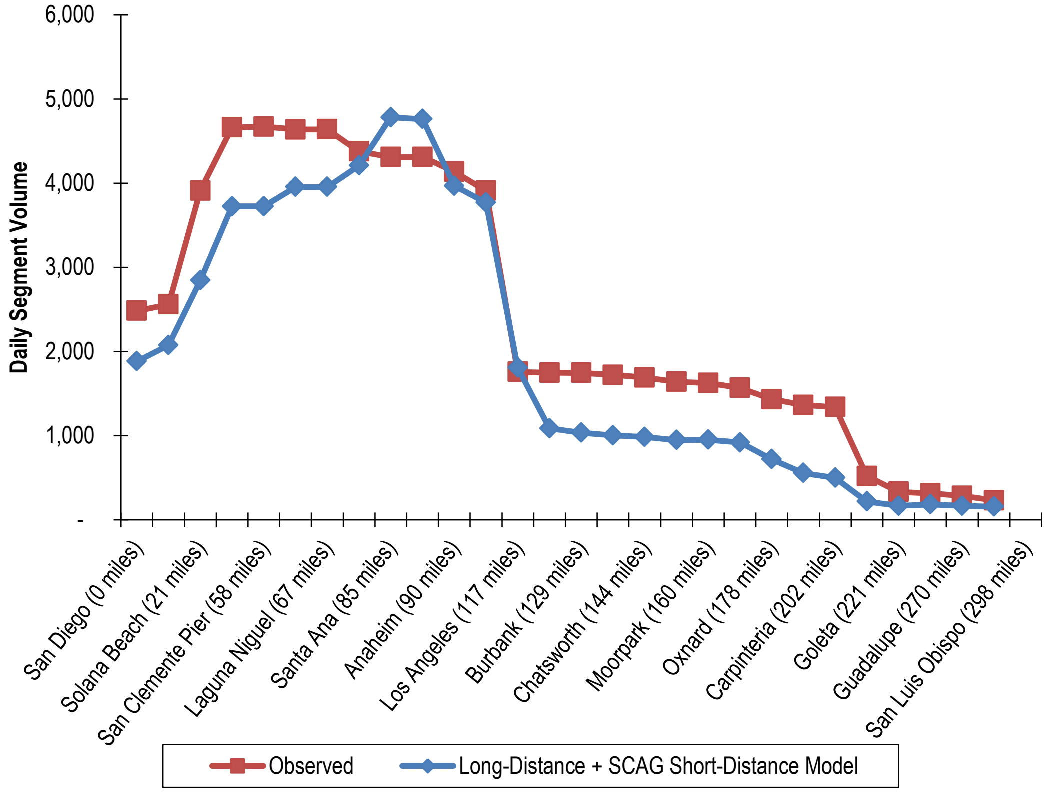


Figure 8.10 shows the Ventura County Metrolink route, extending from Los Angeles Union Station to Montalvo. Modeled conventional rail trips tend to be a little bit high on this route, particularly on the end closest to Los Angeles Union Station. However, the volumes are generally in the reasonable range.

Figure 8.10 Ventura County Metrolink Route: AM Peak-Period Peak Direction Average Daily Loads

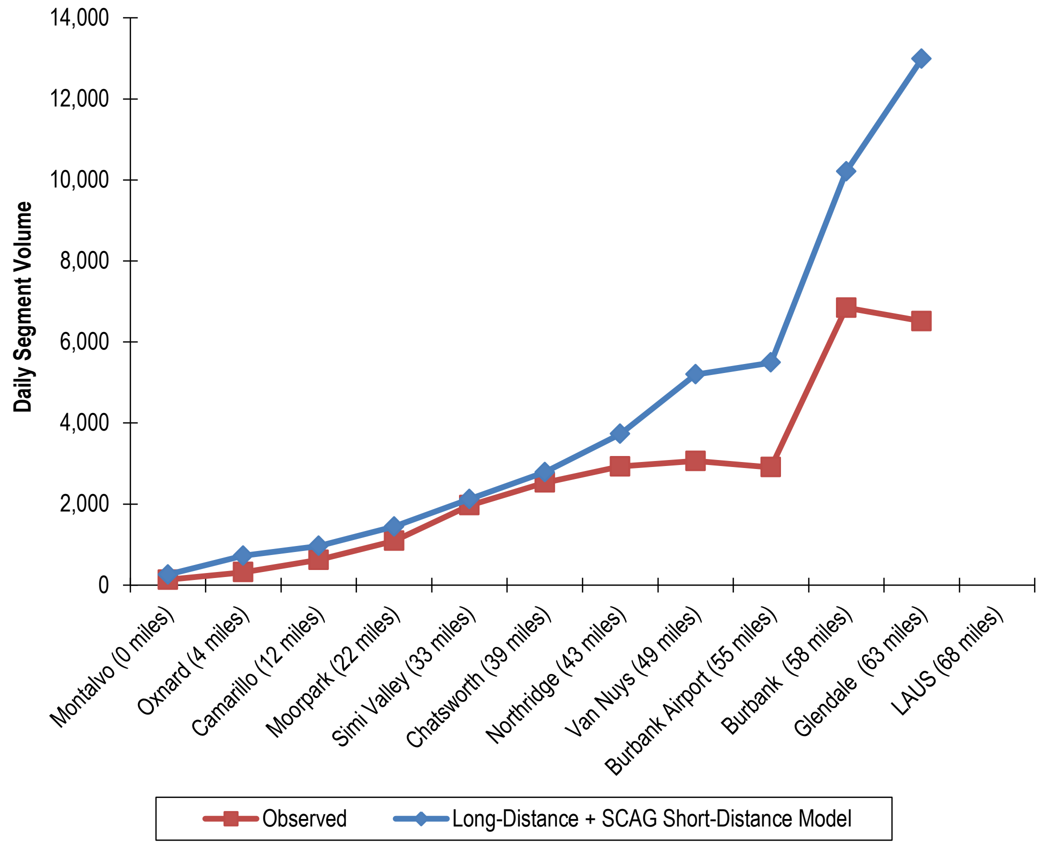


Figure 8.11 shows the Antelope Valley Metrolink route from Lancaster to Burbank, and Figure 8.12 shows the LOSSAN corridor extending from San Luis Obispo to Solano Beach. In both cases, modeled flows tend to be on the low side, but the general shapes of flows across the stations tend to match those of the observed totals.

Figure 8.11 Antelope Valley Metrolink Route: AM Peak-Period Peak Direction Average Daily Loads

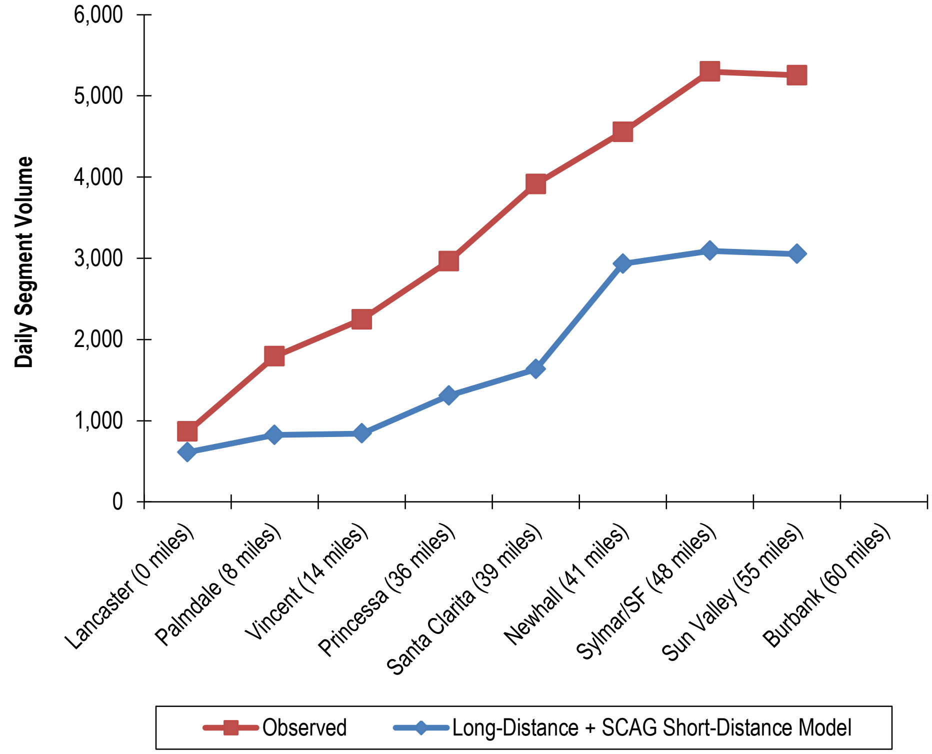
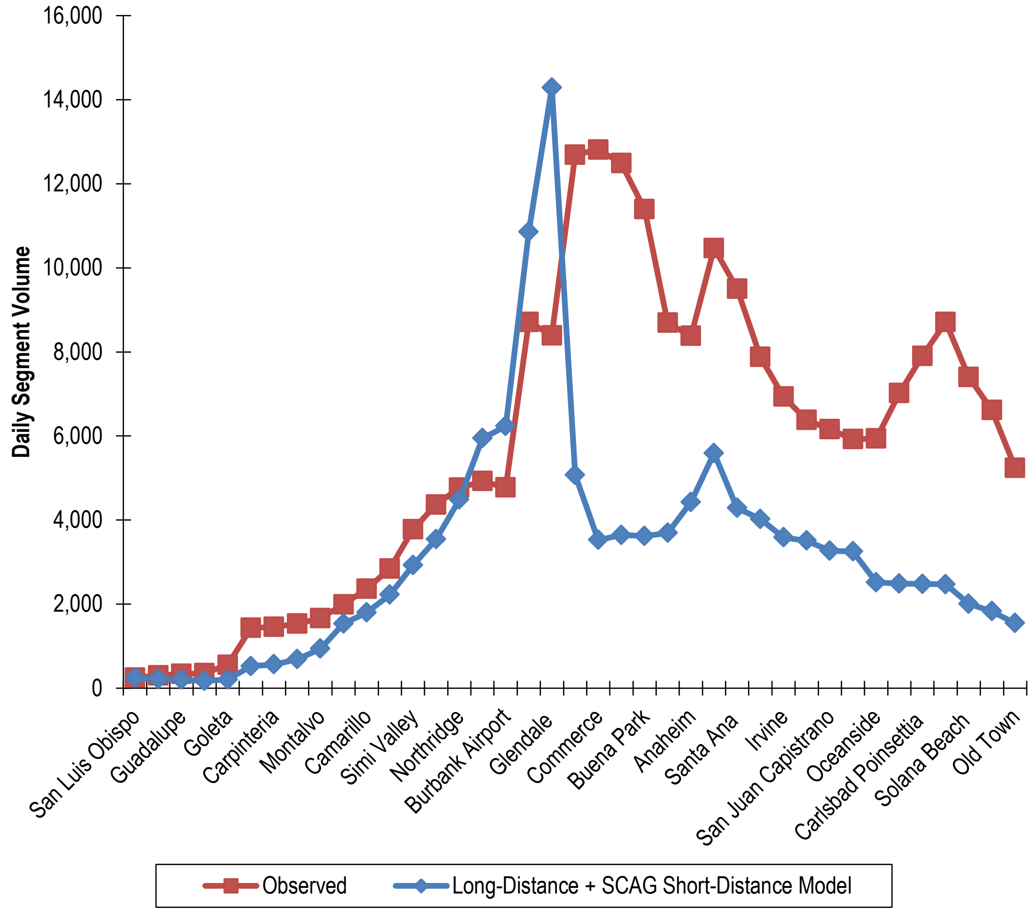


Figure 8.12 LOSSAN Corridor: Average Daily Loads (Amtrak + Metrolink + Coaster)



Air Validation Measures

This section details the validation measures performed based on independently collected air passenger data. The model was estimated and calibrated based primarily on data from the 2012-2013 CHTS. Table 8.6 and Table 8.7 compare modeled annual air trips for 2010 against annual "local" passenger volumes between airports serving those regions.

Observed data have been summarized from the U.S. DOT 10-percent OD survey airline data collected by the BTS. Local air trips in the 10 percent survey data are those trips between the identified airports that are not transfers to or from flights to other locations outside of California. The observed data include non-California residents who had origins and destinations at California airports, as well as international travelers who had an initial domestic origin and a final domestic destination at a California airport. Because of the inclusion of non-

California residents in the 10 percent sample data, the calibrated model was expected to have fewer assigned air trips than the observed data.

The differences between the modeled and observed annual numbers of trips for the region-to-region flows are substantial. However, there is some uncertainty regarding the actual trips and travelers included in the observed data. Due to this uncertainty, we checked the distributions of modeled and observed air trips for the region-to-region flows. The modeled distribution matched the observed distribution reasonably well.

Table 8.6 Annual Air Trips – Validation Comparisons Against 10-Percent Ticket Sample Data

		Observed	Calibrated Model	Difference
SANDAG	SANDAG	0	0	0
	SCAG	26,700	686,900	660,200
	MTC	2,370,700	1,362,000	-1,008,700
	SACOG	678,100	457,300	-220,800
	SJV	32,100	7,900	-24,200
	Other	0	3,100	3,100
SCAG	SCAG	0	0	0
	MTC	7,308,600	4,798,000	-2,510,600
	SACOG	2,014,900	2,054,800	40,000
	SJV	37,500	29,100	-8,400
	Other	4,000	54,100	50,100
MTC	MTC	0	0	0
	SACOG	2,300	159,300	157,000
	SJV	11,700	134,500	122,800
	Other	154,600	32,900	-121,700
SACOG	SACOG	0	0	0
	SJV	900	0	-900
	Other	27,000	4,100	-22,900
SJV	SJV	0	0	0
	Other	0	0	0
Other	Other	0	0	0
Total		**12,669,100**	**9,784,000**	**-2,885,100**

Source: Aviation System Consulting, *Potential Airline Response to High-Speed Rail Service in California*, prepared for Cambridge Systematics, Inc., August 2011.

Table 8.7 Shares of Total Annual Air Trips – Validation Comparisons Against 10 Percent Ticket Sample Data

		Observed	Calibrated Model	Difference
SANDAG	SANDAG	0%	0%	0%
	SCAG	0%	7%	7%
	MTC	19%	14%	-5%
	SACOG	5%	5%	-1%
	SJV	0%	0%	0%
	Other	0%	0%	0%
SCAG	SCAG	0%	0%	0%
	MTC	58%	49%	-9%
	SACOG	16%	21%	5%
	SJV	0%	0%	0%
	Other	0%	1%	1%
MTC	MTC	0%	0%	0%
	SACOG	0%	2%	2%
	SJV	0%	1%	1%
	Other	1%	0%	-1%
SACOG	SACOG	0%	0%	0%
	SJV	0%	0%	0%
	Other	0%	0%	0%
SJV	SJV	0%	0%	0%
	Other	0%	0%	0%
Other	Other	0%	0%	0%
Total		**99%**	**100%**	**–**

Source: Aviation System Consulting, *Potential Airline Response to High-Speed Rail Service in California*, prepared for Cambridge Systematics, Inc., August 2011.

8.3 VALIDATION AGAINST YEAR 2000 DATA SOURCES

The Version 2.0 model was run for Year 2000 conditions. Table 8.8 lays out the key model input assumptions we used for the Year 2000 scenario and the source of the data.

Table 8.8 Year 2000 Source Data and Model Assumptions

Inputs	Source or Assumption
SE Dataset	Adopted from CSTDM year 2000 dataset
Auto Skims	Year 2000 from CSTDM loaded network
Auto Operating Cost	17 cents per mile (2005 dollars)
Auto Parking Costs	Consistent with year 2010
Air Operating Plan and Fares	Year 2000 (developed for Version 1.0)
Air Parking Costs	Consistent with year 2010
CVR Operating Plan and Fares	Adopted from CSTDM year 2000 Input Data
CVR Parking Costs	Consistent with year 2010

Comparison to Version 1.0 Calibration Targets of Total Trips between Regions

Modeled total trips between regions for the year 2000 backcast were compared to the Version 1.0 Model year 2000 calibration targets. The calibration targets were compiled from 2000-2001 CHTS, 1995 American Travel Survey, and 2000 Census Transportation Planning Process. While a statewide travel survey was performed in 2000-2001, it did not include a long-distance travel component. As with the daily diary component of the 2012-2013 CHTS, relatively little detailed information can be derived from the daily diary, alone.

It was difficult to directly compare the calibration targets, because the Version 1.0 Model included all interregional trips, regardless of trip distance. Therefore, only four region pairs were compared directly to year 2000 Version 1.0 calibration targets since they represent regions that are greater than 50 miles apart, as shown in Table 8.9. All other regional pairs include trips less than 50 miles and, thus, cannot be easily compared to the Version 2.0 model results. The results show that the largest HSR regional pair of MTC to SCAG is within seven percent of the observed totals. The other pairs have greater percentage differences, but represent many fewer trips.

Table 8.9 Year 2000 Observed and Modeled Long-Distance Trips (> 50 Miles) between Regions, Greater than 50 Miles Apart
Millions

Region Pairs		Interregional Observed	Calibrated Model	Difference	Percent Difference
SACOG	SCAG	4.2	4.8	0.6	13%
MTC	SCAG	18.3	17.1	(1.2)	-7%
SACOG	SANDAG	0.8	0.6	(0.2)	-24%
SANDAG	MTC	5.5	2.4	(3.1)	-56%

Comparison to Observed CVR Boarding Counts and Segment Volumes

The model results for the year 2000 backcast were compared to observed CVR boarding counts and segment volumes. The CVR data were collected from the CVR operators. As with the 2010 model validation against independently collected data, the backcast CVR trips resulting from the long-distance model and the short-distance intraregional models for the SCAG and MTC regions were assigned to the coded CVR network. Comparisons of backcast segment volumes to observed segment volumes for the Amtrak Capitol Corridor route, the Amtrak San Joaquin route, and the Amtrak Pacific Surfliner route were quite reasonable, especially outside of the SCAG and MTC regions where there was less competition from competing transit services.

Figure 8.13 shows modeled versus observed loads for the ACE service from Stockton to San Jose. Outside of the MTC region, the model predicted segment volumes accurately, while inside of MTC the model overpredicted trips.

Figure 8.13 ACE Average Daily Loads (Observed Data Derived from 2000 On/Off Volumes)

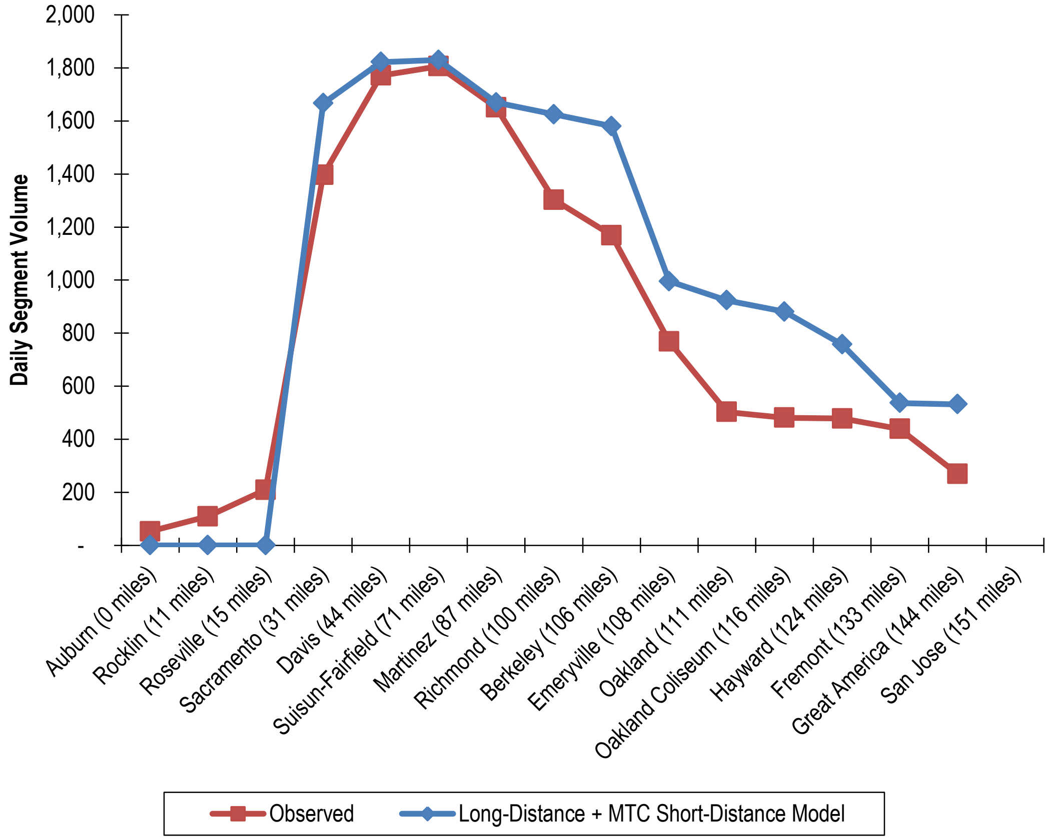


Figure 8.14 shows Amtrak's San Joaquin route running from Bakersfield to Lodi (just south of Sacramento). Model volumes are just slightly high compared to observed, but in general, they are not too different.

Figure 8.14 Amtrak San Joaquin: Average Daily Loads (Observed Data Derived from 2000 On/Off Volumes)

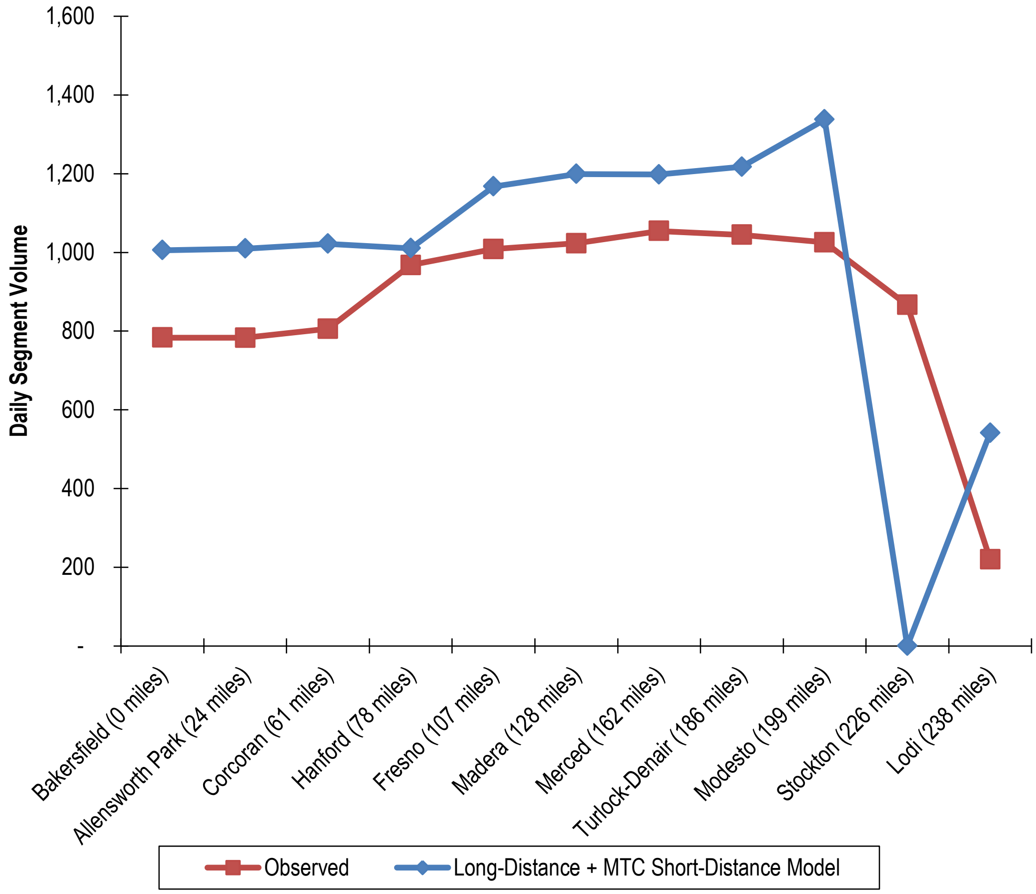
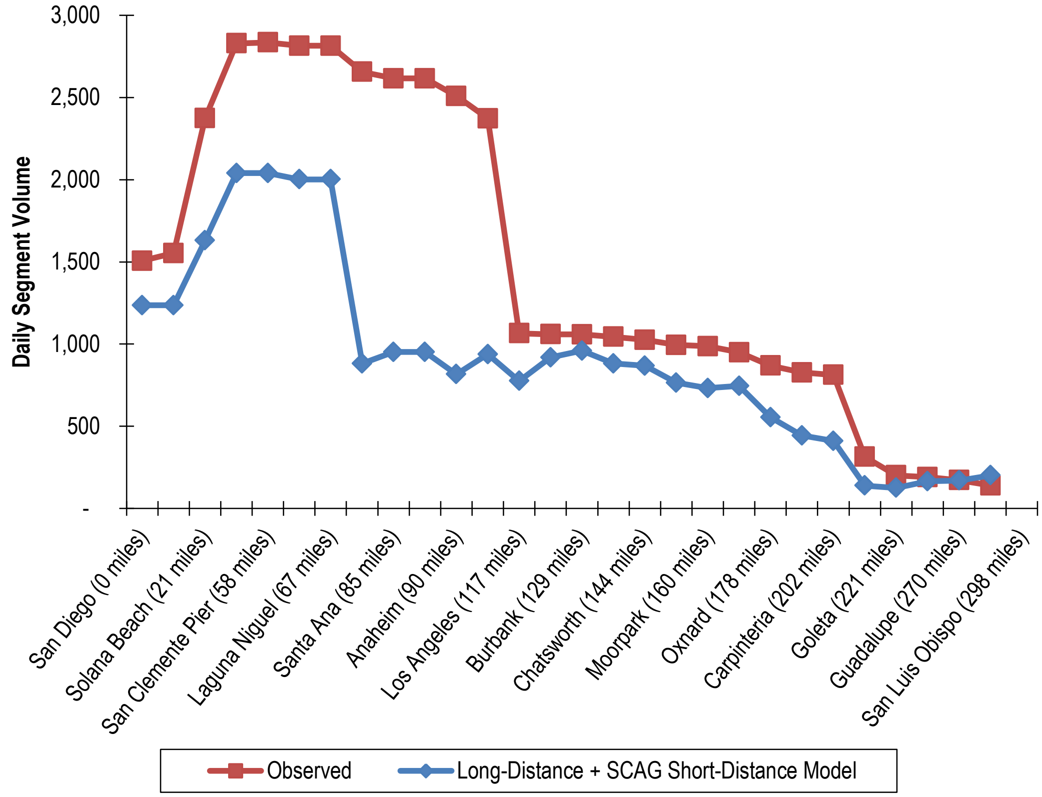


Figure 8.15 shows Amtrak's Pacific Surfliner route, running from San Diego, through Los Angeles to San Luis Obispo. The model underpredicted segment volumes from San Diego to Los Angeles, but matched volumes quite well from Los Angeles to San Luis Obispo.

Figure 8.15 Amtrak Pacific Surfliner: Average Daily Loads (Observed Data Derived from 2000 On/Off Volumes)



Comparison to Year 2000 Observed Air Data

Observed data are based on analysis of U.S. DOT 10 percent origin-destination survey airline data from the Bureau of Transportation Statistics. Table 8.10 compares modeled annual air trips for year 2000 and year 2010 against annual "local" passenger volumes between airports serving key regions. Local air trips in the 10 percent survey data are those trips between the identified airports that are not transfers to or from flights to other locations (outside of California).

The observed data include non-California residents who had origins and destinations at California airports and international travelers who had initial domestic origin and final domestic destination at a California airport. This makes it difficult to determine the validity of the model results, except that we expect the model to produce fewer air trips than the observed data.

It is also difficult to validate the air trips using year 2000 observed data given the decrease in air travel between year 2000 and year 2010. Part of the decrease is due to air travel frequency of service changes captured in the level-of-service input data. It is hypothesized that some of decrease is due to September 11th and the 2008 recession which caused fundamental changes in travel behavior.

One difference in air travel between year 2000 and year 2010 is the increase in security measures at airports which cause increases in terminal time from the entrance to the gate. To test how the model would accommodate this change in terminal time, we adjusted the air mode choice constant so that it reflects a terminal time from entrance to the gate and wait time at the gate to airplane pushback of 47 minutes, which is 30 minutes less than the assumption of 77 minutes used in model estimation and the year 2010 calibration. The reduction in terminal time increased the modeled trips in year 2000, but the number of modeled air trips is still higher for year 2010 compared to year 2000. This indicates that individuals' perceptions of air travel have fundamentally changed between year 2000 and the present, or that the model is failing to account for other differences, such as the effect of the economy on long-distance travel, that have occurred between year 2000 and year 2010,.

Table 8.10 Observed and Modeled Annual Air Trips in Year 2000 and Year 2010 between Key Regions

		Year 2000			Year 2010			Increase in Trips from Year 2000 to Year 2010	
		Observed	Modeled	Percent Difference	Observed	Modeled	Percent Difference	Observed	Modeled
SANDAG	MTC	2,561,453	927,074	-64%	2,370,747	1,361,987	-43%	93%	147%
	SACOG	697,861	311,517	-55%	678,050	457,257	-33%	97%	147%
SCAG	MTC	9,222,404	3,272,400	-65%	7,308,584	4,797,976	-34%	79%	147%
	SACOG	2,250,431	1,395,837	-38%	2,014,861	2,054,844	2%	90%	147%
Total		**14,732,149**	**5,906,828**	**-60%**	**12,372,242**	**8,672,064**	**-30%**	**84%**	**147%**

Table 8.11 Observed and Modeled Annual Air Trips in Year 2000 and Year 2010 between Key Regions Using Reduced Terminal Time for Year 2000

		Year 2000			Year 2010			Increase in Trips from Year 2000 to Year 2010	
		Observed	Modeled	Percent Difference	Observed	Modeled	Percent Difference	Observed	Modeled
SANDAG	MTC	2,561,453	1,147,199	-55%	2,370,747	1,361,987	-43%	93%	119%
	SACOG	697,861	384,502	-45%	678,050	457,257	-33%	97%	119%
SCAG	MTC	9,222,404	4,223,273	-54%	7,308,584	4,797,976	-34%	79%	114%
	SACOG	2,250,431	1,787,471	-21%	2,014,861	2,054,844	2%	90%	115%
Total		**14,732,149**	**7,542,444**	**-49%**	**12,372,242**	**8,672,064**	**-30%**	**84%**	**115%**

8.4 YEAR 2010 SENSITIVITY ANALYSIS

In addition to validation, we performed a number of model runs for year 2010 to assess the model's sensitivity to various changes in LOS characteristics for different modes. This sensitivity testing included evaluating an HSR system that has similar LOS characteristics as the Northeast Corridor and by performing a number of model runs, adjusting one variable at a time, to evaluate self- and cross-elasticities of LOS variables.

HSR Service Levels Approximating those for the Northeast Corridor (NEC)

We forecasted CAHSR ridership and revenue for service similar to the Northeast corridor in the U.S. ("NEC-like") for 2010 conditions, and compared the result to forecasted results for a CAHSRA Phase 1 service for year 2010. The primary value of the NEC-like run is the comparison of the forecasts based on a system with NEC-like service (much inferior to CAHSR) to those from a Phase 1 service to determine if the model is reasonably sensitive to LOS changes.

Table 8.8 compares average station-to-station LOS for NEC-like scenario to the CAHSR Phase 1 scenario. CS developed fare models for the NEC-like system by developing regression models using a year 2008 Acela (the NEC system train service operated by Amtrak) fare table, coupled with distance information to estimate boarding- and distance-based fare components that could be applied for the NEC-like service. The NEC-like fare structure is substantially higher than the fare structure assumed for the CAHSR system. Year 2011 Acela scheduled travel times between stations coupled with distance information were used to develop a regression equation of speed versus distance between stations. The regression equation was then applied to the CAHSR stations to obtain in-vehicle travel times between stations. The resulting average in-vehicle travel times on the NEC-like service were approximately 50 percent higher than the Phase 1 travel times. Average headways between trains for station-to-station movements for the NEC-like service were between 30 and 60 minutes, closely matching the published year 2011 Acela schedule. On average, headways for the NEC-like scenario and the Phase 1 scenario were similar.

Table 8.12 Average Station-to-Station LOS for NEC-Like Scenario and Phase 1 Scenario

	Peak			Off-Peak		
	Phase 1	NEC-Like	Percent Difference	Phase 1	NEC-Like	Percent Difference
Fare (2013 dollars)	$63	$112	77%	$63	$112	77%
In-vehicle Time (minutes)	102	157	55%	111	158	42%
Headway (minutes)	45	47	5%	48	47	-3%

The increase in fare and travel time for the NEC-like scenario compared to the Phase 1 scenario resulted in 52 percent less ridership on the NEC-like system, as shown in Table 8.9. These results indicate that the Version 2.0 model is sensitive to LOS changes. If the CAHSR system was more similar to the Acela service provided in the Northeast Corridor, forecasted ridership would be much lower than the ridership forecast for the proposed CAHSRA system.

Table 8.13 HSR Ridership: Year 2010 Phase 1 versus NEC-Like Scenario

	Phase 1	NEC-Like	Percent Change
Long-Distance (Excluding Intra-SCAG and Intra-MTC)	14.6	5.9	-60%
Total (including Intra-SCAG and Intra-MTC)	**19.7**	**9.4**	**-52%**

Elasticity Analysis

Twenty-eight model sensitivity test runs were evaluated using the year 2010 Phase 1 Scenario. A system characteristic (e.g., travel time) was uniformly factored in each run to produce new estimates of mode use for each mode. Overall mode shares, elasticities, and cross-elasticities for each mode for each run were estimated. The log arc elasticity formula has been identified as the measure that most closely replicates point elasticity and was used for elasticity calculations, as shown in Equation 1.

$$\eta = \frac{\Delta LN(Q)}{\Delta LN(P)} = \frac{LN(Q_2) - LN(Q_1)}{LN(P_2) - LN(P_1)} \quad \text{(Equation 1)}$$

Table 8.14 presents the mode shares and model elasticities based on the sensitivity test runs. In most cases, the Version 2 model is inelastic (i.e., less than 1.0, or that point where a one percent change in the "price" produces a one percent change in "quantity") with respect to changes in the input variables. Auto shares are very inelastic with respect to changes in input variables. This is should be expected since auto generally captures more than 90 percent of the travel market. With the exception of cost, air shares are also inelastic. The air elasticity with respect to cost is close to -1.0.

HSR mode share elasticities have the following properties:

- With respect to cost are inelastic;
- With respect to in-vehicle time are inelastic; and
- With respect to headway are inelastic.

Table 8.14 Summary of Version 2 Model Elasticities

			Mode Shares				V2 Model Elasticities				V1 Model Elasticities				
Mode Modified	**Variable Modified**	**Percent Change**	**Auto**	**Air**	**HSR**	**CVR**	**Auto**	**Air**	**HSR**	**CVR**	**Percent Change**	**Auto**	**Air**	**HSR**	**CVR**
Base		–	94.00%	1.60%	3.60%	0.70%	–	–	–	–	–	–	–	–	–
Auto	Cost	-50%	94.90%	1.30%	3.20%	0.70%	-0.01	0.38	0.18	0.14	-50%	-0.03	0.44		0.49
Auto	Cost	50%	93.00%	2.10%	4.10%	0.80%	-0.03	0.6	0.31	0.25					
Auto	IVTT	-50%	96.80%	0.80%	2.00%	0.50%	-0.04	1.06	0.84	0.71					
Auto	IVTT	50%	89.90%	2.80%	6.00%	1.30%	-0.11	1.35	1.29	1.3	50%	-0.17	1.41		2.11
Air	Cost	-50%	92.90%	2.90%	3.40%	0.70%	0.02	-0.84	0.06	0.02	*-25%*	*0.02*	*-0.53*		*0.01*
Air	Cost	50%	94.60%	1.00%	3.70%	0.70%	0.01	-1.25	0.06	0.01	*33%*	*0.03*	*-0.8*		*0.01*
Air	IVTT	-50%	93.80%	1.90%	3.50%	0.70%	0	-0.23	0.02	0					
Air	IVTT	50%	94.20%	1.40%	3.60%	0.70%	0.01	-0.4	0.03	0					
Air	Headway	-50%	93.90%	1.80%	3.60%	0.70%	0	-0.1	0.01	0	*-25%*	*0.01*	*-0.17*		*0*
Air	Headway	50%	94.10%	1.60%	3.60%	0.70%	0	-0.13	0.01	0	*25%*	*0.01*	*-0.21*		*0*
Air	Reliability	-25%	94.10%	1.60%	3.60%	0.70%	0	0.09	-0.01	0					
Air	Reliability	-50%	94.10%	1.50%	3.60%	0.70%	0	0.1	-0.01	0					

Note: Shaded cells are direct (self) elasticities.

Table 8.14 Summary of Version 2 Model Elasticities (continued)

			Shares				V2 Model				V1 Model Elasticities				
Mode Modified	**Variable Modified**	**Percent Change**	**Auto**	**Air**	**HSR**	**CVR**	**Auto**	**Air**	**HSR**	**CVR**	**Percent Change**	**Auto**	**Air**	**HSR**	**CVR**
Base		–	94.00%	1.60%	3.60%	0.70%	–	–	–	–	–	–	–	–	–
CVR	Cost	-50%	93.90%	1.60%	3.50%	0.90%	0	0	0.01	-0.23					
CVR	Cost	50%	94.10%	1.60%	3.60%	0.60%	0	0	0.02	-0.38					
CVR	IVTT	-50%	93.80%	1.60%	3.50%	1.10%	0	0	0.04	-0.57					
CVR	IVTT	50%	94.20%	1.60%	3.60%	0.50%	0	0	0.04	-0.84					
CVR	Headway	-50%	93.90%	1.60%	3.50%	0.90%	0	0	0.02	-0.24	*-25%*	*0.01*	*0*		*-0.48*
CVR	Headway	50%	94.10%	1.60%	3.60%	0.70%	0	0	0.02	-0.3	*25%*	*0.02*	*0*		*-0.62*
CVR	Reliability	-25%	94.10%	1.60%	3.60%	0.70%	0	0	-0.01	0.25					
CVR	Reliability	-50%	94.10%	1.60%	3.60%	0.60%	0	0	-0.01	0.26					
HSR	Cost	-50%	93.00%	1.50%	4.80%	0.70%	0.02	0.09	-0.42	0.12	*-25%*	*0.04*	*0.37*	*-0.53*	*0.22*
HSR	Cost	50%	94.80%	1.70%	2.70%	0.80%	0.02	0.11	-0.72	0.19	*25%*	*0.04*	*0.44*	*-0.71*	*0.23*
HSR	IVTT	-50%	93.20%	1.50%	4.50%	0.70%	0.01	0.11	-0.35	0.06	*50%*	*0.05*	*0.67*	*-1.05*	*0.24*
HSR	IVTT	50%	94.70%	1.70%	2.80%	0.80%	0.02	0.12	-0.57	0.11					
HSR	Headway	-50%	93.80%	1.60%	3.80%	0.70%	0	0.01	-0.1	0.04	*33%*	*0.02*	*0.12*	*-0.22*	*0.07*
HSR	Headway	50%	94.20%	1.60%	3.40%	0.80%	0	0.01	-0.14	0.05					
HSR	Reliability	-25%	94.40%	1.70%	3.20%	0.80%	-0.01	-0.04	0.43	-0.13					
HSR	Reliability	-50%	94.70%	1.70%	2.80%	0.80%	-0.01	-0.03	0.36	-0.11					

Note: Shaded cells are direct (self) elasticities.